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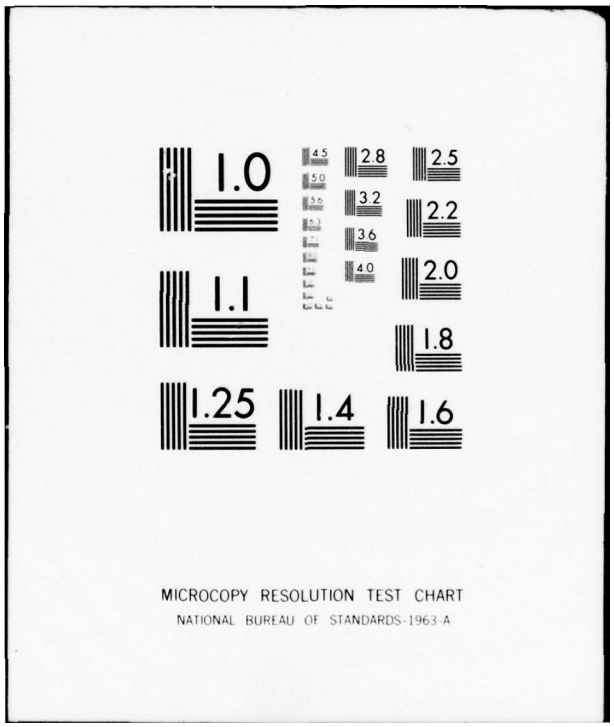
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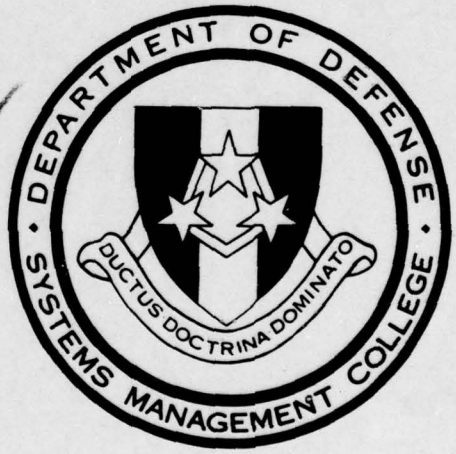
DEFENSE SYSTEMS MANAGEMENT

REVIEW



VOL I, NO 2. SPRING 1977

DEFENSE SYSTEMS MANAGEMENT

REVIEW

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VOL I, NO 2. **SPRING 1977**

DEFENSE SYSTEMS MANAGEMENT REVIEW

PURPOSE

The purpose of the Defense Systems Management Review is to disseminate information concerning new developments and effective actions taken relative to the management of defense systems programs and defense systems acquisition.

The Review is designed as a vehicle to transmit, between persons in positions of leadership and responsibility in the program management and systems acquisition communities, information on policies, trends, events and current thinking affecting the practice of program management and defense systems acquisition. The publication serves as a means for providing an historical record of significant information associated with defense systems acquisition/management concepts and practices.

The Review supports the assigned mission of the Defense Systems Management College, and serves as a medium for continuing the education and professional development of persons in the field.

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DEFENSE SYSTEMS
MANAGEMENT COLLEGE

Dear Reader:

To be assured that the articles appearing in the Defense Systems Management Review are timely, current, germane and of highest quality, we will have several of the very eminent practitioners-of-the-art of program management review the articles that are presented in future issues. These individuals will be identified as Associate Editors and will serve a very important function. The following individuals have agreed to serve in this capacity:

The Honorable Norman Augustine
Vice President, Technical Operations
Martin Marietta Aerospace

Mr. John M. Malloy
Vice President, Administration
Teledyne Ryan Aeronautical

LtGen John O'Neill, USAF (Ret)
President
Armed Forces Relief and Benefit Association

The Honorable Leonard Sullivan, Jr.
Consultant

Mr. John W. Welch
Vice President for Programs
Vought Aeronautical Division
LTV Aerospace Corporation

On behalf of the overall systems acquisition community, the Defense Systems Management College expresses its sincere appreciation to these individuals.

JOHN G. ALBERT
Major General, US Air Force
Commandant

DEFENSE SYSTEMS MANAGEMENT REVIEW

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FOREWORD iii

Major General John G. Albert, USAF, Commandant

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ELECTRONIC TECHNOLOGY PROGRESS AND LIFE CYCLE SUPPORT

- *AN INDUSTRY VIEW*

by

R. M. Lockerd, Texas Instruments Incorporated

Technological change—growth rate technology applications and, the shift from government to commercial direction of "mainstream" technology, have, in the words of the author, been perceived as a potentially serious problem by the Department of Defense. Views on this subject from an industrial, rather than a government perspective are presented here.

The author's vocation is technical and business management in a major US industrial firm that supplies high technology electronic products ranging from basic solid state components through a wide range of end-item components and systems for consumer, industrial, and government users.

INTRODUCTION

For the last two decades engineering, and the world at large, has been subjected to effects of an unprecedented growth rate in new technology applications. This rate of technological change not only has contributed to the general development of "transient" social patterns,[1] but also, has generated significant management problems for some users of sophisticated electronic equipments. As one of the largest of such users, the Department of Defense, in conjunction with a growing concern for realistic budgetary limitations and total life cycle support cost, has perceived this rate of technology change as serious.

Since early 1960 when military applications were the primary driving force in semiconductor electronic evolution, the balance has shifted so that the aggregate of all unique military useage is less than 10 percent of the total semiconductor market, with a

proportionally reduced capability to direct the flow of "mainstream" technology.

Problems associated with Life Cycle Support/Technology interactions have been viewed with varying degrees of alarm by management analysts within the Department of Defense (DOD), with most attention focused essentially at the level of component parts—particularly electronic devices. In summary, the primary concern of DOD might be stated:

> Doesn't the continued rapid pace of new technology development imply that systems being developed today may be logistically unsupportable – by reason of cost and/or parts unavailability – before their planned useful life is complete?

The most frequently cited examples relate to the massive impact of the vacuum tube-semiconductor transition[2] that began in the 1950's and still is affecting DOD logistics in the mid-1970's. Current concerns identify the continuing rapid evolution of semiconductor electronics as a threat to the level of life cycle "supportability." From an industry viewpoint the magnitude of this problem probably is overstated; and, in fact, the situation has much more positive than negative potential on life cycle support costs.

A related, but somewhat separate potential problem is now emerging, triggered by the major technological impact of the programmable function electronics (PFE) now becoming available. The probable long term effect of the advent of this technology on life cycle cost and the supporting logistics system has not yet begun to be widely perceived; but it is clear that it, in fact, may have a substantially revolutionary impact on those aspects of product life cycle management.

A large number of techniques have been suggested[2] for use in managing interactions between life cycle support and technological progress. From an industry viewpoint many of these have limited potential for significant impact, and cannot substitute for a well-planned long term cooperative program jointly executed by the government program team and its industrial supplier. Several of these techniques and some key elements of such a cooperative program are discussed here.

LIFE CYCLE SUPPORT VS TECHNOLOGICAL PROGRESS

DEVICE TECHNOLOGY EVOLUTION – AN OPTIMISTIC VIEW

There is no denying that significant problems are created for long-lived products by the natural tendency of a free enterprise industry to "close out" old, low volume, relatively unprofitable product lines in favor of newer, more cost effective items with greater current and future demand. Industry experience however, has indicated clearly that much more benefit than harm has resulted from the rapid technology evolution, even over the last two decades of "initial transients" in the semiconductor electronics technology. The broad base of system and equipment design experience accumulated over this period has made possible the present capability to anticipate and accommodate future evolutionary trends. Finally, and possibly most important, natural "marketplace" forces in the entire consumer/industrial/governmental market complex are tending to introduce more basic stability than is apparent on surface inspection. On these bases, then, the outlook for the future is very favorable. With a reasonable amount of forethought and management attention, the vast majority of benefits from ever-improving technology can be captured for most existing and new government electronics equipments without large off-setting dangers to the life cycle support aspects.

Revolution or Evolution?

A crucial question in consideration of life cycle support/technology interactions is whether we are experiencing a series of "revolutions" or a somewhat orderly and predictable evolutionary process. Much time and effort has been spent debating this question, and "technology forecasting" is becoming a whole new engineering discipline. In practical terms it appears that the vacuum tube-to-transitor change was revolutionary, but that the process since has been substantially evolutionary, albeit a process proceeding at a high rate and, at some times, with a high "mutant" population. A cursory reading of market growth statistics[3] and projections and of new product surveys,[4] in fact, will produce the impression that the process will continue unabated for the foreseeable future, and this is undoubtedly correct.

The impression obscures, however, some basic underlying evolutionary trends which are very favorable to life cycle support considerations. These trends may be summarized as a tendency for the enormous "momentum" of the current solid state electronics environment to produce natural resistance to noncompatible new developments. This momentum has grown in proportion with the size of the semiconductor applications market over the last two decades, and is a result of the enormous investments already made in fielded equipment, specialized fabrication and assembly capacity, application documentation, other software, and engineering training and experience. The vast majority of this momentum exists in non-DOD electronics market segments, so much so that it effectively directs the mainstream of electronic developments.

The major observable effect of this momentum is the establishment of both formal and "de facto" standards for semiconductor devices at basic physical and electronic interface levels. It is now, for example, much more difficult than only a few years ago to introduce and hope to sell, in significant quantities, a new semiconductor component that does not have Transistor-Transistor Logic (TTL) interface capability, and/or that does not utilize one of a very few commonly accepted packages such as the dual-inline integrated circuit form factor. Even where new developments are needed for specialized users, e.g. high-density component packages for the makers of avionics equipment, industry-wide standardization[5] precedes their introduction in significant volume. The net effect of these trends has been to "damp out" much of the wide variation in basic types of devices and packaging seen during the earlier days of semiconductor development. Yet, it has not, and will not, put significant limitations in the growth of capability, e.g. the growth from 1K-bit of memory per package to 16K bit per package; but it does mean that there is now a much greater ability to

- anticipate evolution in design by appropriate modularity, and
- execute logistically compatible performance/cost improvement design changes as requirements and/or budgets dictate,

with consequent favorable effects on life support capability.

Design Updating to Technology

The enormously favorable impact of technology evolution on the cost and fuctional capability of electronic systems is unquestionable, not only in military systems, but in providing functions at very nominal cost which literally were not available at any price only a few years ago. Today's hand-held scientific calculators, for example, provide for a few hundred dollars as much or more directly useable computational ability than was available for fixed computers occupying whole rooms and costing several orders of magnitude more in the mid-1950's. Despite highly favorable trends in the initial cost of electronic capability, concern over low cycle cost implications has focused on the difficulty of obtaining "obsolete" components for required repair or replacement of fielded systems. Although vacuum tubes are the most prominent single example, it is true that a significant number of earlier semiconductor device types such as germanium transistors, Diode-Transistor Logic, and even "flatpack" integrated circuits are now difficult to procure. The other side of this coin is that in essentially all cases these items have been replaced with items of substantially improved performance and/or cost; and, in fact, their very obsolescence was usually caused by the appearance of a substantially "better mousetrap." Industry experience has indicated that, whether done voluntarily or as an inescapable necessity, the process of "updating" systems to newer component types has consistently improved some combination of function, reliability, and "maintainability" and, thereby, lowered the forward life cycle cost. In fact, it is typically the case that the usual management of "mainstream," highly useful DOD systems, accommodates any such needed changes as a part of the normal process of product sustaining, value engineering changes, etc. Typically it is only the marginally useful and/or lower population systems that encounter significant problems; and a very real problem element exists in the older equipment which the US government has provided to other countries. Even in these latter cases, the technical problems are not insurmountable. The basic issue is managerial—whether the systems' future utility justifies an investment to extend their life. No user ever likes to give up an inplace capability, but the real world principle of "growth or death" clearly applies to electronic systems as to most other functioning entities.

THE COMING IMPACT OF PROGRAMMABLE FUNCTION ELECTRONICS (PFE)

It is impossible to pick up a current electronics publication without encountering an article on microprocessors, bit slices, or some other element of the family of Programmable Function Electronics (PFE). As semiconductor devices these PFE represent only basic evolution in technology; but they will ultimately precipitate a revolution in the way most DOD electronic equipment and systems are designed, produced, and logistically supported.

Basically, the PFE are simply large, highly integrated digital semiconductor circuits that instead of performing a completely "hard wired" logic function, have the ability to perform a variety of operations as directed by external "program" inputs or by the configuration in which they are "wired" into the system. The "hardware" standardization inherent in the use of PFE produces very low cost per function because of the high production volume for each single device design. Depending on the PFE device type, program inputs may come from fixed prewiring or switch setting, or from the full range of stored program possibilities offered by ROM*, PROM*, RAM*, EPROM*, etc.

The desired function is first generated as "software" by which the programmable device is ultimately to be directed, then subsequently committed to "hardware" by appropriate inclusion in the circuits controlling the PFE. Because of both the economic and functional appeal of PFE for implementation of most reasonably complex digital functions, it is probable that the majority, if not almost all, digital electronic systems developed from this time on will employ some forms of PFE.

From a life cycle support point of view, there are many significant aspects of the emergence of PFE applications that will require close attention of both the electronic system developers and the ultimate users. A few of these aspects are:

- The systems development cost will swing toward much higher "software" content. As the existing and somewhat artificial distinctions between "software" and "hardware" blur finally disappear, both government and industry management must anticipate and accommodate merging of the two disciplines.

- Basic digital hardware reliability will improve as device and interconnection counts are reduced, and the raw production costs of digital capability will decrease significantly.

- Within fixed volume, power, and/or weight restraints, significantly more digital "horsepower" can be provided. This capacity can, and should, be devoted to self-supporting maintenance functions such as built-in test, remote "monitorability," and/or redundancy for reliability as appropriate.

- The basic flexibility of systems to accept post-development functional changes will increase in proportion to the software content. This is good news for the direct user, but potentially bad news for the logistician; and rigorous discipline will be required to force realistic function/life cost tradeoff to justify system modifications.

- To a large extent "throw-away" replacement of many digital functions will become not only possible but clearly advantageous as hardware costs decrease and more functions are packed into single, large integrated circuit elements.

- The logistical burden will be simplified at the piece-part level with one PFE replacing many other integrated circuits. Also, the high volume useage of PFE elements will act to ensure their availability over a long time span.

- Problems of software maintenance and logistics, which have previously been confined to a relatively few computer users, will become much more widespread, offering a significant challenge to logistic management.

In summary, the unavoidable advent of PFE elements will have a significantly favorable impact on life cycle support of digital electronics—but will place a relatively new burden of software control on the logistician responsible for long term system maintenance.

*(Read Only Memory, Programmable ROM, Random Access Memory, Electronically Programmable ROM)

MANAGING LIFE CYCLE SUPPORT/TECHNOLOGY INTERACTIONS

Management of the development, deployment, and support of electronics systems—whether composed of relatively few similar "black boxes" or a number of major subsystems of widely varying types—requires a never-ending balancing of intricately involved factors, some of which are due to the interaction between technological progress and life cycle cost and/or product "supportability." From an industrial viewpoint, knowledge and consideration of the following factors are key to the proper management of life cycle cost/technology interactions:

- Recognizing the *real world cost* of technological life
- *Giving heavy weight to the use of "mainstream" technology*
- Recognizing and utilizing the *natural roles of government and industry*
- Facing up to the *procurement implications of minimum life cycle cost* over extended life
- *Realistically planning and controlling* for deliberate life cycle cost and lifetime characteristics

The following paragraphs expand on each of these areas, but it will be readily recognized that they all unavoidably interact and must be considered together as a normal part of the systems management function.

THE REAL COST OF TECHNOLOGICAL LIFE

The old principle of "There's no such thing as a free lunch" applies very well to the question of life cycle cost for long-lived electronic systems. In the simplest terms, there is an absolutely unavoidable cost base involved in supporting any product over a long useful life and someone, sometime, will pay the bill. This cost can be minimized by proper management—by sharing "pooled" costs through commonality in "mainstream" technology or standard parts; by making the right investments at the right times in tooling, stockpiling, etc.; by including life cycle cost considerations in initial design guidelines; etc.—but in no case is the cost eliminated, although it can be concealed, deferred, or sometimes "put on the other guy." Industry's present sophisticated management methods, many of which have evolved over the last two decades, are keyed to Return-On-Assets or Return-On-Investment; and clearly illuminate the fact that items with lowered production volumes always develop very real cost problems. These problems are cumulative with time and are typically so large that continued production is unfeasible unless some user needs the item(s) so badly that he is prepared essentially to buy and maintain the assets that are required for their production. This effect is often emotionally characterized as an industry "rip-off" of "captive" users, which clouds visibility to the real fact that the cost is there and someone must bear it. As unpalatable as the fact may be to the user, either production volume or direct costs must be supplied to continue supporting basic manufacturing capability, and the more sophisticated the product, the more this rule applies.

The implications of these facts to the government systems manager is that he is offered an opportunity relatively early in the life cycle of his product to recognize and plan for these costs, or ignore them and be surprised later. Recognition of these basic factors usually requires life cycle planning for both periodic design-updating investments to minimize forward life cycle cost and for realistic and substantial cost escalation for additional systems and/or spares after the main production phase of the program is past. As the character in a current television commercial says, "You can pay me now or pay me later."

THE VALUE OF MAINSTREAM TECHNOLOGY

It is first useful to consider what constitutes the "mainstream" of solid-state electronics technology. While the flow of this mainstream carries with it a multitude of specific devices, the most fundamental aspect is not the particular *device types* but the *processes* by which they are made, and the resulting

physical and electronic interfaces with the "outside" world. The basic value of mainstream participation is due, essentially, to one factor—it is possible to share the cost of development, production, and the maintenance of availability over life with many other users rather than bearing the cost alone.

Because unique or, at least, distinctive requirements exist in many military electronic systems, the temptation almost always exists to develop specialized devices for the implementation of these requirements. There is also a large segment of industry with specialized circuit capability whose basic existence depends on "selling" the need for such developments and their subsequent production; and they provide an important and needed function. Conversely, probably one of the most valuable traits that could exist in a modern electronics program manager is a healthy skepticism about the need of and/or wisdom of such developments. In fact, a "zero-base-budgeting" approach starting with "Why can't we use commercial devices" would be useful in many cases. Some basic ground rules are:

- When possible, use commercial devices either directly or with screening at the "bar" production level* for subsequent military qualified packaging.

- When using PFE devices, be prepared to "overkill" the hardware capacity in places to utilize common, standard device types that are running well below their maximum capability.

- If a unique circuit is required, don't develop one involving basic processes *not solidly in the mainstream.* The cost of developing and maintaining a unique semiconductor process capability is enormous and almost impossible to amortize over any realistic volume for defense equipment alone.

- A corollary of the above is that the use of special "hybrid" devices should be carefully evaluated. Almost without exception, if size, etc. permits, *separate digital and analog circuits will minimize ultimate life cycle cost.*

- Avoid the lure of greatly *understating the future cost* of special devices. The cost/volume laws that control semiconductor costs are as inexorable as entropy. Beware of suggestions that the device will "catch on in the commercial market." A good test is that if a major semiconductor manufacturer can't easily be interested in developing the device—beware. The *cost* of a "special" can also skyrocket if the original vendor should disappear or lose interest.

To illustrate these effects, a gross comparison of some present and future semiconductor products of the various types mentioned is of interest. Some typical data are shown in Table 1. While the absolute values presented will vary with time and other circumstances, the ratios can be expected to remain essentially fixed and the cost of uniqueness, even for relatively high volume special circuits, may be clearly seen. The logic power/cost impact of the PFE, in this case a microprocessor, may also be seen, both at the present and projected to the near future when the use of PFE will become more pervasive.

GOVERNMENT AND INDUSTRY ROLES

The natural responsibilities of the government system manager in system requirements definition, interface with the ultimate users, operational testing, and initial deployment are clear and distinct from industry's role in fabrication and initial system testing. This distinction of natural and most effective roles is not, however, nearly so clear in two key areas – system design and post-production support. It is these two areas, both of which heavily impact LCC, that most challenge the coordinated management skills of the participants. Whole volumes have been written on this subject, and it obviously is not appropriate to address these issues fully here. Some observations on LCC/technology implications are, however, offered for the consideration of potential program managers:

- In the design phase, both parties must be *willing* and qualified to participate jointly on a very candid basis in life cycle cost projections. If the task is done alone by either government or industry, or under contraints of "finding the known answer," the effort will probably not be

***Manufacturing point where the device has not yet been packaged.**

TABLE 1

Relative Digital Electronic Costs

TTL Device Type*	*Package*	*Cost (Dollar/logic "Gate")*
Custom, hi-environment, "hardened"	Special	2.00 – 5.00
JAN TX TLL Logic	Ceramic DIP**	0.25 – 0.30
Screened SNC-SNJ***	Ceramic DIP**	0.12 – 0.18
Commercial	Plastic DIP**	0.05
Microprocessor with military environment capability	Ceramic DIP**	0.15 present (0.01 – 0.005 in mature production

*Transistor-Transistor-Logic
**Dual Inline Package
***SNC Reliability Screened for MIL STD 883B; SNJ Dual Inline Ceramic Package Integrated Circuit

worth its cost. In unique cases, one or the other party might be qualified to do life cycle cost alone, but such cases would be few. Remember that understanding LCC theory or having a nice computer model is not the same as really projecting life cycle cost. The old computer adage of "garbage-in/garbage-out" applies.

- In the design phase more than lip service must be paid to life cycle cost. Investing dollars now to save later, or settling for less capability now with more to be added (easily) later are issues that must usually be raised by the designer and *quickly and decisively* evaluated by the government managers. The cost of a delayed or deferred decision can easily cancel out or exceed the potential savings if a "tight loop" is not maintained.

- The industrial supplier will have a "handle" on lower tier suppliers, know the system or equipment, have management continuity in the technical areas involved, and have facilities for repair, renovation, etc. The government manager must be prepared to evaluate the possibility of commitments to extended contractor support early in the program, so that proper decisions can be made on tooling, facilities, and stockpiling. If this support is integrated with planned design updates by the supplier, the overall cost will be lowered, and significant LCC reductions and useful life extensions will result.

PROCUREMENT IMPLICATIONS

The value of competition in our free enterprise system is unquestionable, and the basic concept is so deeply ingrained in our thinking that it is difficult to ask objectively, "At what point may competition become disadvantageous to the buyer of a product?" This is, however, a question to be carefully considered in the life-cycle management of modern DOD systems. In particular, life cycle support and cost/technology interactions have significant implications in terms of how the procurement of systems and equipment may best be structured to accommo-

date competition. For example, in an environment of dual-source, design-to-life cycle cost competitive developments, the traditional government attitude toward long-term, sole-source commitments should be restudied. With the plethora of cost accounting standards, program cost reporting, inprocess and postcontract audits, and resident government inspectors; the old specter of excessive profits by a sole-source vendor can be laid to rest. The necessity for, and effectiveness of, compulsory re-competition for additional production, spares, etc. is probably much more psychological and political than practical in terms of reducing overall life cycle cost and developing the potential for extended system life. The possible benefits of selecting a single supplier for long-term product commitments are many:

- A vendor with visibility to long term return on investment is able to take much larger "front-end risk," that can result in lower government LCC. In development phases, these investments may appear as supportive IR&D and/or cost sharing of developments; in later phases, as self-funded development of "value engineering" proposals to incorporate technological developments for improved function, lower life cycle cost, etc.

- Vendors with long term visibility can afford significantly greater investments in facilities, tooling, and other resources that may improve product quality, reliability, and/or a vendor's ability to respond rapidly to changing production or technology requirements.

- With longer visibility, the primary vendor has much more leverage to negotiate favorable price, specification, and delivery agreements with lower tier suppliers; and their product may also show some of the beneficial effects of manufacture in a more stable demand environment. Longer continuity of product availability may also result.

- All of the contractor support advantages that have been noted may be obtained and the government logistic system is not burdened with handling nearly as many individual part types.

In summary, long-term commitments to "single source" suppliers for government electronics systems can, and should, be favorably considered as means to improve life cycle support/technology interactions.

In discussing the topic of sole source commitments for product life support, the question is asked,"Doesn't it mean that smaller outfits will get driven out of business by the big primes"? The answer to this is definitely "NO," and, in fact, it is probable that most smaller, lower tier suppliers had much rather do business under these circumstances. Smaller companies with good quality products benefit from a predictable market even more than larger ones; and, when part of a stable team, actually feel the benefit of a "buffer" with more staff capability to predict business trends, manage the government interface, and quickly fix problems. On this basis, the lower tier suppliers benefit more than the "prime" from long term commitments to product support by the government.

SOME MANAGEMENT TECHNIQUES

Many techniques for controlling life cycle support/technology interactions have been suggested, studied, and discussed by both government and non government system managers. A recent paper in this publication presented a survey of some of the more important of these techniques, and summarized one government manager's view on their use.[2] Brief comparative comments from an industry viewpoint are presented below on a few of the techniques:

- Modular design

- Standard parts

- Stockpiling

- Reliability improvement warranties

- Scheduled, life cycle support-oriented product design updates

Modularity

Modularity of design has a number of well-known attributes, most of which bear directly on life cycle cost, for example, economy of volume in production and field "maintainability"; but its effects on life cycle cost/technology interaction are equally important. In this connection it is important to recognize that modularity must be looked at on multiple levels—not necessarily confined to the "Line-replaceable module" popular in logistics. For example, in the implementation of solid-state memories it is possible to anticipate progressively higher densities in interchangeable packages e.g. 1-K bit RAMS* are beginning to be supplanted by 16-K bit packages, which, in turn, will almost certainly be joined by higher density devices. If effects such as these are considered ("designing for technology") in initial system architecture and partitioning phases, the cost of later inclusion of such elements can be minimized and the logistics pipeline smoothly "turned over" to newer technology products.

Standard Parts

The use of standard parts is closely allied to that of modularity and, like motherhood, is unquestionably necessary and, usually, desirable. The real question devolves to one of how "current" it is possible to maintain standard parts lists for high technology products. Experience has shown that government-controlled standard parts lists lag the best current component availability by at least 1 year, and more typically 2 or 3; with critical items like semiconductors and connectors presenting the worst problem. Some lag is inevitable, but the implication again is that the government manager must be prepared to deal rapidly, competently, and with an open mind with his industrial counterpart on questions of non-standard parts. Large development programs, like a waiting taxi, always have the "meter running," and delays for relatively minor parts deviations can cost literally thousand of times the parts' worth in development costs.

The development of families of standard function modules, such as the US Navy's SEM (Standard Electronic Modules) is an approach with much appeal for the government logistician; and is also, in general, favorably viewed by most industry managers, but with some strong reservations, e.g.:

- The cautions noted about the inherent cost of substantial deviation from the mainstream will have to be carefully observed, or the expected favorable cost impact could rapidly reverse to become a major cost burden.

- More highly specialized and integrated functions—particularly of "hybrid" circuits—are more vulnerable to technological obsolescence; and the inertial effect of standard "stockpiles" may dictate continued use of out-of-date technology, thus severely impacting design capability by unacceptably prebiasing normal cost/function tradeoffs.

Stockpiling

"Stockpiling" as a hedge against technological "rollover" on parts availability is probably one of the highest risk, least productive techniques. Electronic component stockpiling, in particular, is risky unless done very carefully, because the stockpiling effort usually completely "closes out" production capability for the devices in question. Further, "sampled" quality test procedures which are quite acceptable for "production" items are inadequate for stockpiling. These components are intended to be "all there is" with no realistic subsequent recourse to vendors for repair or replacement. This means that 100 percent inspection and testing including, if possible, stress testing should be done as any item is stockpiled. Resources for storage, and retrieval, also must be furnished for the intended life of the product.

Reliability Improvement Warranty

While the case for utilizing the relatively new concept of Reliability Improvement Warranty as a tool for managing early product life cycle support is reasonable, it is at best, a questionable one for dealing with long term life cycle support/technology interactions. During the relative short term of the Reliability Improvement Warranty the contractor is "on the hook" to keep sources of supply active for the product, but this is typically not the part of a product life cycle where technological "rollover" problems exist. Unless the durations of the Reliability Improvement Warranty are drastically extended, it appears unlikely that they will make any significant impact on life cycle support/technology interactions.

*(Random Access Memories)

Planned Design Updates

Probably the most powerful technique for managing life cycle support/technology impact is the use of planned, periodic "design updating" by either the original designer or an equally competent source. These exercises should be scheduled and budgeted as a normal part of the product life cycle. In most cases, the "raw" cost of these updates will be a small fraction of the total product life cycle cost; and industry experience indicates that the forward life cycle cost savings will normally more than repay these costs. In the past, the reduction in forward life cycle cost has been associated with "step function" improvements in reliability and/or "maintainability" made possible by the the availability of new technology and more product experience. It should be emphasized that these efforts are not to be "changes for the sake of change," but must incorporate fundamental analytical techniques to demonstrate clearly the forward life cycle support advantage of any proposed change. The analyses must include, at a minimum, weighing of life cycle cost impacts from changes in reliability and maintenance requirements, as well as the value of introducing improved functional capabilities.

SUMMARY

In considering interactions between Life Cycle Support and Electronic Evolution from an industrial viewpoint, the following summary observations may be made:

- The overall detrimental impact of rapid technology development probably has been substantially overstated. With proper attention to management and technical considerations, technological improvements can be incorporated routinely after the development phase, both to enhance functional capability and to reduce forward life cycle costs.

- There will be a significant impact on basic electronic systems design and life cycle logistics from the advent of more highly integrated, "programmable" function electronics. Preparation should begin to accommodate routinely the associated "software" logistics, that will impose a major new stress on the overall logistic system.

- The key to managing life cycle cost/technology interactions is a fundamental understanding of the cost and availability factors for "mainstream" versus "unique" electronic components. Those performing realistic life cycle planning must recognize that there is a real price to be paid for product lifetime, and early provision made for both minimizing and paying this price.

- Particularly in the case of long-lived, complex electronic systems for which competitive, design-to-cost developments have been done, the leverage of long-term commitments to a single contractor should be utilized. Modification of existing procurement policies may be required to implement.

- Probably the most powerful management tool for optimizing life cycle support/technology interactions is the introduction of planned design updates during the normal product life cycle. Such updates will typically repay their cost many-fold by reducing forward life cycle cost through reliability and other improvements; and, frequently will increase functional capability and extend the product's useful lifetime.

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SOFTWARE VISIBILITY AND THE PROGRAM MANAGER

by

Alan J. Driscoll, LtCol, USAF

Software and the Program Manager—What is software in the terms of a Program Manager? How can he manage software development in his program? The virtual explosion in the use of computer resources in modern weapon systems emphasizes the need for an understanding of computer software. Attempts to use inadequate software, lax software control, and the problems associated with software misuse, have been addressed repeatedly in current literature and speeches.

Software visibility is explained here by an Air Force author who tells how software problems affect costs, schedules, and performance; how to combat these problems; and, why software is of urgent importance to Program Managers.

PART I

INTRODUCTION

THE SITUATION

Software has meaning to a Program Manager only in terms of how it relates to his total program. Software, like hardware, is important in terms of cost, schedule, and performance, therefore it must be given the same type of management attention that is given hardware. Lack of this type of management attention has been all too evident. The result has been that problems in the early developmental phases—problems such as inadequate requirements definition and improper integration of hardware and software requirements have been aggravated—then magnified in later phases—by other problems such as inadequate staffing and the inability to measure software development progress.

Affirmative action such as putting software at a high level in the Work Breakdown Structure and including software in the Systems Requirements Analysis (SRA) can alleviate many pervasive problems. None of the many actions required to avoid the problems can be accomplished without early, long-term planning.

To those professionally concerned with systems acquisition it is not surprising that there is a rising level of interest in software on the part of the government. This is especially true of the Department of Defense (DOD). The interest is due in part to the extremely high cost of software—regarded by many persons as being "merely" data. The key for any Program Manager in obtaining suitable software is to elevate software—remove it from the category of "data" and plan for its development on a level of importance with hardware.

SOFTWARE IMPORTANCE

For most weapon system development programs that incorporate both hardware and software, the computer software is a critical component relative to the overall operation of the system. (Mangold,[1] p 13). There are two reasons why the Program Manager should be concerned with the software of his system. First, software performance is critical to the success of his program. Second, his software will receive high-level attention. The need for an error-free computer program is obvious in the case of the guidance and control flight software for a missile such as the Minuteman Intercontinental Ballistic Missile (ICBM). Here a minor software error can cause inflight failure of a vehicle costing millions of dollars. An undetected flaw can seriously degrade the operational missile force. Although an error may not cause such spectacular results in many systems, schedule slips, rework, and degraded performance can escalate cost in a comparable manner.

The Need to Know

What does the Program Manager need to know and be concerned about regarding the software in his weapon system? Essentially, he needs to know the same basic things that he is required to know about his hardware. The basics are:

- Does the software meet performance requirements?
- Is the software within cost?
- Is the software on schedule?

In the "DOD Weapon Systems Software Management" study report prepared by Johns Hopkins University, it is stated that a lack of software visibility, when compared with that of hardware, contributed to the fact that software was not well managed.[2] The report also said that visibility could be increased by putting software on a par with hardware (Johns Hopkins,[2] p 2–4) and addressed ways of accomplishing this equality.

System Responsibility

This article is limited to software associated with embedded computer systems although some of the material presented may be applicable to general automatic data processing (ADP) systems. The research conducted was directed to systems that are under the purview of the Air Force 800 series regulations. Study was centered on the management of software from the viewpoint of a Program Manager who has responsibility for both hardware and software—the total system. *

Research and Governing Documents

Research for this article was conducted in three separate but related investigations. 1) The results of a search of current literature on problems that Program Managers encounter in software development, and potential solutions to those problems, are presented in Part II. 2) A review of applicable DOD Policy, Directives, and Regulations, is presented in Part III. In Part IV a summary and observations are presented.

SOFTWARE COSTS

Since the advent of the digital computer, the ratio of software costs to hardware (the computer and related peripheral equipment) costs have undergone enormous increase. This phenomenon is represented in Figure 1.

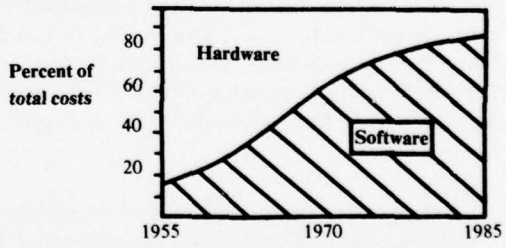

Figure 1. Hardware/Software Trends
From *"Defense Management Journal,"* Vol II(4): 24 (1975).

Similar charts have appeared in many publications and are commonly accepted as the conceptualization of increasing software costs. To Program Managers this situation raises the question: How can I get control of system software? How can I place emphasis upon software from where I stand?

*** In this article software development activity is discussed only to the point when a completed computer program is ready for operational use. The operational, maintenance, and modification aspects of software are not discussed in any detail.**

Relevance

The relevance of increasing software costs to Program Manager actions becomes clear when consideration is given the high number of weapon systems that contain computer systems. In an *Aviation Week* Conference Report, Jacques Gansler, Deputy Assistant Secretary of Defense for Materiel Acquisition, said that a Pentagon study "identified 115 different defense systems that employ "embedded computers" of which approximately one-half are now in service and the other half are under development." (Aviation Week,[3] p 43). Gansler is also quoted as saying "According to our estimate, the Pentagon is spending more than $3 billion annually for software for defense systems." (Aviation Week,[3] p 41). He went on to state that 68 percent of the amount is spent during system development and 32 percent is spent for operating and maintenance costs. Another estimator of software costs states that "Current annual expenditures for embedded computer systems exceed $2 billion, with more than 70 percent of this amount dedicated to software."[4]

This amount of money is obviously not a trivial sum, yet cost is only one facet of the software picture. The other side of the story is unsatisfactory software performance, or, more simply, its unreliability. Barry C. DeRoze, Directorate for Weapons Support Systems Acquisition, Office of the Assistant Secretary of Defense (Installations and Logistics), has said:

> "Although hardware reliability has improved substantially, the corresponding gains in system reliability have not been realized. This apparent contradiction arises because software unreliability—the failure of software to satisfy the stated operational requirements—has become the "tall pole in the tent" in determining the reliability and operational readiness of systems." (DeRoze,[4] p 3).

Further indication of the high-level interest in software is expressed in the statements made by the Director of Defense Research and Engineering to the 94th Congress, Second Session, 1976:

> "The urgent need for reducing the costs of computer software was described in last year's Posture Statement. A DOD Directive resulting from a comprehensive study is currently being coordinated that will require the use of improved procedures in software acquisition. A DOD Software Management Steering Committee has been formally established to: (1) review DOD software technology programs, (2) recommend needed areas of research and emphasis, and (3) plan a balanced and coordinated software program."[5]

Management Visibility

Numerous studies have been made to ascertain how to improve the management of software. One of the foremost themes noted is the need for "management visibility" of software. For example, one of the four subelements of the main objective of the DOD Weapon Systems Software Management Program is "to promote management visibility."[6]

This then leads us back to the purpose of this article: To determine and report just what "software visibility" means to the Program Manager.

PART II
Software Management Ideas

THE PROCESS

To talk about software cost, schedule, and performance without covering the various steps in the software development process is almost impossible. It is difficult to separate cost, schedule, and performance, and it is very difficult to determine what the Program Manager should do to obtain visibility for each of these separate, yet closely related, factors. Here, the software development process is discussed along with the relation of cost, schedule, and performance visibility to each phase in the development process.

Definitions

The software development process has been defined by many people in many different ways. These steps range from the seven steps expressed by Eldon R. Mangold (Mangold,[1] p 2–8) to the three steps of Boyd Etheredge (Etheredge,[2] p 21).

Steps in the Process

The steps in the software development process as *defined by Mangold:*

1. System requirements
2. Software requirements
3. Preliminary design
4. Detailed design
5. Code and debug
6. Test and preoperations
7. Operation and maintenance

The steps in software development process as defined by Etheredge:

1. Analysis and design
2. Implementation and test
3. Delivery and maintenance

In writings about the cost of developing large-scale software programs, R. W. Wolverton discusses what he calls the 40–20–40 rule. (Wolverton,* p 13). The rule was developed empirically and says that the total resources (cost) for software development will be split 40 percent for analysis and design, 20 percent for coding and debugging, and 40 percent for checkout and test. I have used a slight variation of these three phases that I label:

- *Analysis and Design.* This step includes the first four steps of Mangold's process.
- *Implementation.* This is the code and debug step of Mangold and Wolverton.
- *Verification.* A step essentially the same as the checkout and test step of Wolverton.

Various tools and ideas suggested by writers in government and industry as linking cost, schedule, and performance visibility throughout software development are examined here.

ANALYSIS AND DESIGN

Analysis and design begins with a definition of system requirements and progresses through the development process to software allocation to achieve complete design. The latter is a critical step that will affect the total development cycle. The criticality of establishing system requirements and software requirements is stressed by Winston W. Royce.

> "...In our judgment the single most important cause of poor management of software projects is the inability to successfully accomplish these first two phases of requirements analysis." (Royce,* p 1–13)

Royce goes on to say that without requirements analysis the *first* step in software development is design. This, of course, is a prelude to disaster. In actuality there are probably no projects where design is done without someone *thinking* they have defined the requirements. The real question then is: How do you know or ensure that the requirements have been defined in a proper manner? One step is to get the user involved. The ultimate requirements are his. Again quoting (Royce,* p 1–21):

> "...The user of the software must be capable of injecting his expertise into the software product..."

and

> "...A complete, detailed, accurate set of performance and implementation requirements which has been fully coordinated with the user is the first step in ensuring compliance with operational requirements." *

The Program Manager must ensure that his software people are involved in the total system engineering process, and interface directly with the user. Software requirements must be considered from the beginning by the user and developer in relation to all other system requirements. The Program Manager should have this in mind as the program progresses from a Required Operational Capability through the system specification to the computer program specifications. He should insist on the participation of the user in all design reviews.

Requirements must be defined early and with specificity. In the case of requirements that cannot be defined at the start, a schedule for such definition

should be established and the software planned in accordance with the schedule. Too, the Program Manager should plan the development schedule to accommodate changing requirements. He should remember that software is affected by nearly every change in the weapon system design. (Bartlett,[10] p 6).

The latter statement suggests another point: the integration of hardware and software requirements. One aspect of this is the software/computer relationship. Obviously, the computer can have a big effect on the software, but the reverse effect may be even greater. The use of higher order languages is being promoted for development of defense software although the use of a higher order language is sometimes less efficient in terms of the required memory capacity and the speed of the computer. (Aviation Week,[3] p 41). The issue here for the Program Manager is to ensure that his systems engineering people plan for the fact that perhaps a larger, faster machine is required if the software cost, schedule, or performance (or all three) are not to be adversely affected. One recommendation of the DOD Weapon Systems Software Management Study, conducted by Johns Hopkins University, was to require that computer systems be sized to provide for uncertainties and requirement growth. As stated (Johns Hopkins,[2] p 6–22):

> "...It is a basic feature of software that it can accommodate change provided it is not limited by hardware capacity or speed. Accordingly, an important part of software systems engineering is the judicious and controlled provision of growth capability."

Aside from the software-computer relationship, there is the larger relation of software to total system requirements. In *Government Executive*, August 1975, General Phillips, the Commander of the Air Force Systems Command was quoted as saying:

> "We have come to the conclusion that we must engineer software in much the same way we engineer hardware...What all this boils down to is a full systems engineering approach to software development."

The process of applying system engineering to a requirements definition is often referred to as Systems Requirements Analysis. The effective use of Systems Requirements Analysis, particularly as it relates to software, is an area to be pursued by the Program Manager. (Bartlett,[10] p 14).

The effects of an adequate or inadequate requirements analysis or definition ripple through all phases of software development, including design. Changes in requirements cause changes in design and these in turn usually cause schedule changes. (Software changes continue throughout a project for a number of reasons including: requirements changes, hardware deficiency accommodation and new or modified interfaces. (TRW,[11] p 1–2)). Changes in schedule will, at a minimum, increase costs, and may preclude the meeting of all performance requirements. Ideally, every step should be completed prior to starting the next. According to Eldon R. Mangold:

> "From a management standpoint, it is essential that the successive steps in the development process be restricted until the preliminary design is completed." (Mangold,[1] p 2–13).

In some programs, schedules have been so tight that coding was begun before an adequate analysis of program design could be performed. (TRW,[11] p 5–24). Again, the Program Manager must exert every effort to protect the program against the cost and schedule impacts of changes. Two areas where the Program Manager can accomplish this are, first, in planning and secondly, in configuration management.

> "The planning of a computer program development is probably the source of fifty to seventy-five percent of all development problems. Planning does not have to be bad to lead to problems; but it must be exceptionally good to avoid them." (Bartlett,[10] p 10).

The above quote serves to emphasize the importance of planning. Planning pervades the entire development process. Substantive, early planning can assist in the avoidance of problems by providing schedule flexibility, and adequate computer size.

The application of configuration control to software is not new, but deserves top management attention because of its importance during build up of the architecture and logic as well as later. One of

the problems with software management in the past has been that software was treated simply as data, not as a deliverable contract line item and thus did not get the same visibility as did hardware. The Johns Hopkins study recommended that major computer software involved in weapon systems development be designated, during full scale development, as configuration items and deliverables to include:

1) operational software;
2) development support software, and
3) test and integration software. (Johns Hopkins,[2] pp 2–5, 2–11).

The Air Force has taken steps to implement this recommendation.

Formal configuration management of software begins with the approval of the development specification that occurs about the time of preliminary design review. The preliminary design review also provides the first clear look at the software design and reflects the matching of the requirements to the design. Although the Program Manager cannot be expected to attend every design review in his program, he should stress the importance of these reviews to his software manager.

IMPLEMENTATION

Implementation is the step during which the design is converted to program code and debugged (or tested) to eliminate any errors that may exist (there will be errors). The analysis and design phase, although not easy to track, has some visible means of measuring progress that are similar to those for hardware (written requirements, flow charts, an analysis and design specification, etc.). The implementation phase poses different problems; it is difficult to find an appropriate way of determining status. Quoting (Johns Hopkins,[2] p 2–6):

> "The abstract nature of software makes it difficult to measure progress and, hence, makes it even more necessary to formalize the steps in design, implementation, and test. The lack of such definition leads to difficulties in interface management and to the late discovery of inadequate requirements or design errors, with resulting slippages in schedules and increases in cost."

Problems

There are two basic problems involved here. One, it is the inclination of programmers to do the interesting work at the expense of dull work (documentation). Visible signs of programming progress are almost totally lacking. Another set of difficulties arises from the nature of the product. There are virtually no objective standards or measures by which to evaluate the progress of computer program development. (Wolverton,* p 1). Because of this situation we have what is known as the 90 percent syndrome. (Aviation Week,[1] p 42). This is expressed in Golub's Law #12 that says:

> "...projects progress quickly until they are 90 percent complete, and then they remain 90 percent complete forever." (Grooby,[12] p 252).*

The Program Manager has several means at his disposal for tracking cost and schedule in any project. Among these are the Cost Performance Report (CPR) and, for smaller programs, the Cost/Schedule Status Report (C/SSR).** In the past these means have not been satisfactory for obtaining software visibility primarily because software was treated as "data" and/or was so low on the Work Breakdown Structure (WBS), if there at all, that it was never seen.

Milestones

The recommendation has been made that software be put in the WBS at a level equivalent to a hardware subsystem. (Borklund,[13] p 31, Johns Hopkins, [2] p 2–4). This would increase the visibility and understanding of software.

The question arises: "Is the CPR or C/SSR type information on software meaningful, even when available?" The CPR or C/SSR information will indicate whether the contractor is spending money at the rate he projected, but perhaps nothing about what actual progress has been achieved. If some set of measurable milestones is not established, progress

*** This is one of "Golub's Laws of Computerdom," some humerous, but all too true expressions of what can go wrong in computer/software development.**

**** Discussed in detail in AFR 800–6 and AFSC Pamphlet 173–3.**

will be measured in terms of time or dollars expended, that is, if 100 hours are estimated for a task and 100 hours have been expended then the task is complete.(Kieder [14] p 55). The estimating of cost and schedule for software (coding in particular) has been inaccurate and emphasizes the need for discrete milestones to evaluate progress. A series of design reviews (system, preliminary, critical) is at least a partial answer. In the Johns Hopkins report milestones are discussed and reference is made to MIL-STD-490, MIL-STD-483, and AFR 800–14, Vol II, noting that milestones are indicated in these documents but the work to be accomplished and the products that are to be delivered are not defined. The Johns Hopkins report did not reference MIL-STD-1521, a Standard that does define work and deliverables for design review and audits.

One approach to measurement has been proposed that I call the "all or nothing" system. In this system the project is broken into discrete tasks (for example, the coding of a module, component checkout, etc.) but attempts are not made to estimate or measure progress within the tasks. For any given task, progress is reported as either 0 percent (from start to almost finished) or 100 percent, the point at which the task is physically complete. This approach takes away the guesswork and eliminates the "90 percent syndrome." The Program Manager should be very careful about how much faith he places in the reports he receives (e.g., the CPR and C/SSR reports are only as valid as the estimates that go into them; and estimates for software have been notoriously inaccurate.)

VERIFICATION

Verification is the third of three phases that make up the software development process. Design is established in Phase One. Phase Two is the Implementation Phase where software is coded to satisfy the requirements, and Phase Three, the Verification Phase, determines whether or not Phase Two was successful in translating the requirements and design into a computer program that satisfies the operational needs of the user. Verification can take many forms, from a manual review of code to operational flight testing. One author describes verification as three interrelated functions. First is Code Verification, the process of determining whether the actual code is implemented in compliance with the computer program specifications. The second function is Validation, the process of testing the coded program against the specified design and performance criteria. The third function is Certification, where the testing process is extended to an operational (either real or simulated) environment. (Reifer, [15] p 22). Regardless of how the verification phase is defined, it is imperative that all requirements be tested against some measurable criteria. A requirement for which a feasible test does not exist or for which a test has not defined should not be allowed. (Bartlett, [10] p 6). The task for the customer (and therefore the Program Manager) is to ensure that all requirements can be tested.

Test Plans

To ensure that all requirements can be tested, consideration of the testing methods and criteria must be accomplished during requirements definition. The Program Manager must ensure software visibility in this process and emphasize its importance to his software people. The Program Manager will not be able to get directly involved at the lower levels of detail, but he can influence attention to software through insistence on thorough planning. Software test plans must be written to the same level of detail as the requirements in the development specifications. The test plans should require that each performance requirement of each computer program configuration end item be verified in some appropriate manner. Acceptance criteria should be specified. (Richards, [16] p 68).

Independent Verification

The discussion of software verification to this point has been restricted to that done by the developing contractor. An adjunct to verification by the developing contractor is the use of an independent verification contractor—an excellent means of providing software visibility for the Program Office and the Program Manager. (TRW, [11] p 5–9). This practice originated with a requirement for the independent check of software to insure nuclear safety and is becoming widespread. The practice, known as Independent Validation and Verification (IV&V), has been expanded to include software performance as well as nuclear safety criteria. When used properly, the IV&V contractor can provide the Program Manager comprehensive knowledge of all phases of software development. Because of having to verify that

requirements have been met, the IV&V contractor is in an excellent position to provide feedback as to the testability of the requirements and the design at early design reviews.

GENERAL

Some additional means for obtaining software visibility, that apply throughout the development process, follow.

Methods of Contracting

The method of contracting employed to obtain software can have an effect on the ability of the Program Manager to obtain visibility. These methods of contracting include:

- Selection of a single contractor to develop a total system with the software treated as one of the contractor's several tasks, or
- Selection of one or more contractors to develop the software and another contractor to develop the hardware.

There are other variations of course, and there are advantages and pitfalls in all of them. N. E. Bolen, writing in "An Air Force Guide to Contracting for Software Acquisition," addressed the subject as follows:

> "...The single system contract has the advantage of making one organization responsible for system performance."
>
> "However, there is danger that the software development effort will not receive proper management attention and resources within the contractor's organization. (Bolen,[17] p 7).

Under the cited circumstances, the Program Manager must take deliberate action to ensure software visibility in development. Bolen went on to say:

> "...Dividing the system acquisition into separate contracts so that one contractor is responsible for software alone provides the potential for better Air Force visibility of the contractor's progress;..."

Only the potential for increased visibility is provided by a separate software contract and the practice is not without potential problems. Among these could be a hardware/software integration problem that could place a considerable burden on the Program Manager's organization and staff.

Staffing

One of the problem areas in software acquisition identified by the Johns Hopkins report was the technical staffing of the Program Manager's organization. The report cited a lack of personnel experience in system engineering and software development as contributing to:

- Lack of policy guidance and planning, and
- Inadequate cost and schedule monitoring.

The Program Manager should get the best staff possible.

Aside from the number and quality of personnel on the staff, organization of the staff can also make a difference. The ways of organizing vary widely from *vertical, or aggregate, through matrix. Also there* are different forms of project approaches. Stephen P. Kieder, in an article entitled, "Why Projects Fail," discussed (what he called) the "Utilization Philosophy":

> "...A most fundamental problem which affects many large companies is one which demands maximizing the utilization of personnel, as opposed to a project-oriented approach." (Kieder,[14] p 55).

Kieder explained that he was talking about the reassignment of people whenever there is a lull in the work and the continuity problems that occur when later these people return to a former job or are replaced by another person. In Kieder's words:

> "...This is a disastrous approach because while it assures that people are always assigned to a project and utilization is high, it places an emphasis upon effort, not results."

Although Kieder's comments were directed toward the use of programmers in a large company, there is a lesson to be learned in terms of using personnel in such a way as to maintain continuity throughout any project. Keider also emphasizes the need to have one man responsible for the entire software project and not fragment responsibilities to the point where no one person is accountable. (Kieder,[14] p 54).

PART III

Authority and Constraints

The high-level attention given to software in recent years has fostered regulations and manuals having the purpose of producing software that satisfies the constraints of cost, schedule, and performance. For USAF programs, these documents cover the span from Department of Defense Directives to Air Force Systems Command (AFSC) pamphlets.

DEPARTMENT OF DEFENSE DIRECTIVES AND POLICY

DODD 5000.1, "Major System Acquisitions"

Department of Defense Directive 5000.1 does not make specific reference to software. This directive establishes policy for the acquisition of major programs (major programs are defined in DODD 5000.1) and management principles applicable to all programs." This directive applies to software as well as to hardware.

DODD 5000.29, "Management of Computer Resources in Major Defense Systems"

This directive establishes policy for the management and control of computer resources during development, acquisition, deployment, and support of major Defense systems." The DODD 5000.29 applies to major programs as described in DODD 5000.1; in addition, the principles apply to the acquisition of Defense systems that are not in the major acquisition category.

The DODD 5000.29 is a relatively new document (26 April 1976) and the intent is that it will not be in existence long, but that its policies and principles will be assimilated as an integral part of the established process of acquiring major Defense systems.

The most significant part of DODD 5000.29 is Section V, Policy, that, in general, states that computer resources in Defense systems must be managed as elements or subsystems of major importance during all phases of the life cycle with particular emphasis on computer software.

To ensure the early consideration of computer resource (including software) requirements, DODD 5000.29 requires they be included in the DSARC II * Review. To accomplish this, DODD 5000.29 lists the following items to be implemented in the Concept Formulation and Program Validation Phases of development:

- Risk analyses
- Planning
- Preliminary design
- Security definition
- Interface control definition
- Integration methodology definition

The risk areas, and a plan for their resolution shall be included in the Decision Coordinating Paper.

Another statement of policy is that computer software will be specified and treated as a configuration item.

To identify acquisition and life cycle planning factors and guidelines, a computer resources plan will be developed prior to DSARC II and maintained throughout the life cycle. (The Air Force plan that meets this policy requirement is discussed under AFR 800–14, Vol II.)

In parallel with the policy of making software a configuration item is the requirement to specify unique software support items as deliverables with DOD acquiring rights to item design and/or use.

Of particular interest to the Program Manager is the requirement for milestone definition and specific criteria to measure the attainment of these milestones. This requirement, of course, fits with the requirement to consider software as elements or subsystems of major importance, and the necessity to deal with software as a configuration item.

* Defense System Acquisition Review Council II.

Another item of policy which could have a significant impact is:

> "...DOD approved High Order Programming Languages (HOLs) will be used to develop Defense system software, unless it is demonstrated that none of the approved HOLs are cost effective or technically practical over the system life cycle." (DODD 5000.29[19] p 3).

The DODD 5000.29 has made into DOD policy many of the suggested solutions to software problems that were reviewed in Part II of this article. A continuation of this trend is foreseen.

AIR FORCE REGULATIONS

AFR 800–14, Vol I, "Management of Computer Resources in Systems"

This is an especially important document inasmuch as it is the first in the series of Air Force acquisition or management oriented regulations to specifically address software. The stated objective of AFR 800–14, Vol I, is to:

> "...insure that computer resources in systems are planned, developed, acquired, employed, and supported to effectively, efficiently and economically accomplish Air Force assigned missions."

In Section B of Vol I, the Program Manager is given the responsibility to:

> "Provide management and technical emphasis to computer equipment and computer program requirements identified in the Program Management Directive." (AFR 800–14,[20] p 3).

There are several parts of AFR 800–14 that are of particular interest to the Program Manager from a software viewpoint. Under the heading of Air Force Policy the regulation states:

> "...Computer resources in systems are managed as elements or subsystems of major importance during all life cycle phases."

Although some programs had in effect done this for years, for most programs implementation of this requirement represents a significant departure from previous practice. The policy has a ripple effect into all aspects of software development. Also under Air Force policy is a paragraph enumerating those items that "...Program Management Directives require and Program Management Plans provide for." (AFR 800–14, Vol I,[20]). Some of these items are:

a. Establishment of computer technical and managerial expertise responsive to the Program Office which is independent of the system prime or the computer program development contractor, and, is preferably, an organic capability of the Program Office.
b. The specification and allocation of system performance and interface requirements to be met by .... computer programs.
c. The identification of .... computer programs as Configuration Items.
d. Work Breakdown Structures (MIL-STD-881) designed to facilitate identification of computer resource costs.
e. Coverage of .... computer programs during the conduct of system design reviews, audits, and management assessments.

Each of the five items mention an area of concern from past software experience.

Item a can be interpreted as the charter for one very real way in which the Program Manager can provide for software visibility—through organization. The Program Manager should exercise the flexibility given him by AFR 800–2 to set up a Program Office organization having a specific focal point for management of the program software efforts. The need for this was noted by Kieder in his article, "Why Projects Fail." (Kieder,[14] p 54).

The provision of AFR 800–14 stated in Item b could be a fallout of the earlier stated policy of software being "...elements or subsystems of major importance." (AFR 800–14, Vol I,[20] p 1). Because the Program Manager cannot be expected to review all system and interface specifications it is important that the Program Management Plan provide for proper treatment of software in the systems engineering process. The importance of correct definition of software requirements in the systems engineering process is difficult to overemphasize.

AFR 800–14, Vol II, "Acquisition and Support Procedures for Computer Resources in Systems" (An Air Force Working Group will review implementation of these procedures.)

Procedures that apply when implementing the policies of AFR 800–14, Vol I, and other publications that pertain to the acquisition and support of computer resources, are consolidated in Vol II of AFR 800–14. Volume II restates applicable portions of related publications and must be used with those publications. (AFR 800–14, Vol II,[21] p 1–1).

Planning. Planning is discussed in Vol II as it relates to several specific functions. There are three planning functions in particular that are software peculiar: The Computer Resources Integrated Support Plan (CRISP), the Computer Program Development Plan (CPDP), and the Computer Resource Working Group (CRWG).

The Computer Resources Integrated Support Plan identifies organizational relationships and responsibilities for the management and technical support of computer resources. This is a cradle-to-grave plan for computer resources that assigns responsibility for all areas of software acquisition and support. As such, CRISP has great potential to aid or hinder the development of software within the constraints of cost, schedule, and performance and should receive the effective backing of the Program Manager.

The Computer Program Development Plan is the development plan for software. Preparation of this plan is the responsibility of the implementing command, but the plan may be (and usually is) prepared by the contractor. This is a complete, detailed, development plan and is to contain items of particular interest from a software visibility viewpoint. Among these items are the contractor's development schedule for each Computer Program Configuration Item (and the proposed milestone review points) and the procedure for monitoring and reporting the status of computer program development.

The Computer Resource Working Group has as its prime purpose the preparation of the CRISP. The CRWG is initially chaired by the Program Office and has representatives from the implementing and supporting commands. Because of its membership and its purpose, the CRWG can be very useful when integrating requirements and in getting the user involved.

Engineering Management. Engineering management as applied to computer resources is described in terms of the system engineering process. One objective of engineering management is "...that computer resources are managed as an integral part of the total system." (AFR 800–14, Vol II,[21] p 4–1).

Although all reviews can aid in obtaining software visibility, one aspect of critical design reviews should allow them to provide additional visibility, i.e., "...the CDR may be performed in stages as the logical design of Computer Program Components or groups of components is completed." (AFR 800–14, Vol II,[21] p 7–4).

Testing. Tests of computer programs will be conducted under the same general ground rules as system hardware. (The principles of AFR 800–14 apply to testing of computer resources.) (AFR 800–14, Vol II,[21] p 5–1). Development Test and Evaluation is divided into Configuration Item test and system level test. Each Computer Program Configuration Item (CPCI) must be tested and established as a qualified item suitable for the system level test.

Configuration Management (CM). As specified in AFR 65–3, CM will be applied to each Computer Program Configuration Item throughout the system acquisition cycle. (AFR 800–14, Vol II,[21] p 6–1). Volume II of AFR 800–14 is explicit in this requirement and requires that computer program configuration management not be fragmented from the overall system configuration management. Reiterated are the procedures for applying configuration management to any part of a system (i.e., software being no different from hardware). One software peculiar item is the use of a Computer Program Identification Number (CPIN) for each CPCI. The CPIN is assigned by Air Force Logistics Command.

The identification of computer programs as configuration items in recent years has alleviated one of the major software problems of the past, specifically the control of changes and maintenance of a known baseline. Software baselines are now established and changes are controlled through the Engineering

Change Proposal system. Because of the relative ease with which software can be changed there is a great tendency to use software to correct hardware/design errors and deficiencies that become apparent late in system development. This usage takes advantage of one of the inherent characteristics of software and is not necessarily wrong. There is, however, a danger of not recognizing the great impact minor changes can have on schedules and costs owing to the additional, and required, testing and verification.

Although the regulation states that configuration management will be applied to each CPCI, it does not provide any guidelines as to what computer programs should be Computer Program Configuration Items. In many instances certain items of support software built by the development contractor should be designated deliverables (and CPCI) in addition to the operational software. This support software may be either that required for support during the production/deployment phases, or software tools usable in the development of other operational software. The Program Manager should ensure that his staff is aware of his policy on support software and that, when appropriate, such software is designated as a Computer Program Configuration Item(s).

Documentation. Documentation is needed during development to track progress and provide information for management visibility and decision making. (AFR 800–14, Vol II,[2] p 7–1). This statement emphasizes one of the more important aspects of software, i.e., the only way to see progress in software (or the end product) is through documentation. This is not true of data. Data management in general is handled through a data management office in accordance with AFR 310–1 and through the use of techniques such as deferred ordering, deferred requisitioning (described in AFR 310–1 and Armed Services Procurement Regulation ASPR, Section 7), and an accession list.

Volume II, AFR 800–14 lists five categories of documents usually prepared by the contractor and used for performance monitoring: Configuration management, engineering, test, operation, and support. Of particular interest are specifications (engineering documents), because they document requirements and the actual computer program as coded. Computer program specifications are written in accordance with MIL-STD-490, MIL-STD-483, and MIL - S - 83490. To quote from AFR 800–14, Volume II:

> "Specifications provide the basis for documenting requirements, controlling the incremental development between major program milestones and providing visibility."

Contractual Requirements. Contractual requirements are discussed in the regulation but, while different means of including software in the contract for a prime contractor are described, mention is not made of the possibility of a separate contract(s) for software. The point is made that the Program Manager should ensure that instructions to those who bid provide for preliminary contractor plans that describe the computer program development concept.

Computer programs should be identified at Level Three in the project Work Breakdown Structure. This statement is of major significance to the Program Manager. In a major program particularly, such as an airplane or a missile system, placing software at Level Three * of the project WBS could pose some problems as well as provide some real benefits. On the benefits side:

> "Identification of computer program configuration items at Level Three of the WBS will provide the visibility necessary to evaluate cost, schedule, and performance of contractor efforts." (AFR 800–14, Vol II,[2] p 8–2).

Conversely, if there is a large amount of software, consisting of several computer programs associated with different hardware (and perhaps being developed by different contractors) placing all software at Level Three of the WBS might not be feasible nor desirable. It might be quite difficult to correlate the WBS and the specification tree with the actual manner of software procurement.

*** MIL-STD-881A, "Work Breakdown Structures for Defense Material Items," has a series of appendices that show a summary Work Breakdown Structure for several types of systems (e.g., aircraft, missile, electronics). The only systems for which software (computer programs) is listed at Level Three of the WBS is electronics systems. Software is not shown at all in the other system's WBS.**

In the regulation AFR 800–14, Vol II, software is discussed as a contract deliverable. The statement is made that "contract deliverables are specified as line items in the contract," and that "while computer programs and documentation must be listed on the DD 1423,* the DD 1423 should be identified as an exhibit or attachment depending on the required management emphasis." (AFR 800–14, Vol II,[21] p 8–2). An AFSC supplement to the ASPR, Section 9–603, expands on this direction. This supplement also requires computer software/computer programs/computer data bases to be specified as line/subline items in the contract schedule. There is still a dual treatment of software as a line item and as "data". This is handled by requiring that delivery of computer software/computer program(s)/computer data base(s) documentation be specified on separate DD Forms 1423 — DD Forms 1423 separate from those that specify the actual cards, tapes, etc.

OTHER GOVERNING DOCUMENTS

AFSC Pamphlet 800–3, "A Guide for Program Management"

The general considerations involved in managing the acquisition of a system are described in AFSCP 800–3. The pamphlet is intended as a guide and does not specify inflexible procedure through which all program goals are achieved. (AFSCP 800–3,[22] p 1–1). The acquisition process is traced through its different phases, and a general description of the principal functions involved in managing systems acquisition programs is given. The portions of the AFSC Pamphlet 800–3 that are of interest to the Program Manager from a software peculiar viewpoint follow.**

- A System Design Review should address the allocated requirements for computer programs and interfacing equipment. (AFSCP 800–3,[22] p 8–5).

- In the discussion of Critical Design Reviews, AFSCP 800–3 states the purpose of a CDR for a CPCI is to establish the integrity of computer program design at the level of flow charts or computer program logical design prior to coding and testing. (AFSCP 800–3,[22] p 8–5). This view of the CDR in relation to the software development process is an idealistic one. In practice, the exigencies of schedule and money will often force coding to start prior to CDR. In fact, some software managers consider the CDR as a logical event to separate coding from the start of validation/verification.

- Under the heading entitled, "Configuration Management," software is mentioned only to the extent of pointing out that the selection of Configuration Items below prime-item level is a management decision accomplished through the systems engineering process and that each computer program is identified and documented by one macro flow chart. (AFSCP 800–3,[22] p 9–4).

- "Data Management is the only chapter that has a section devoted to software. This section of AFR 800–3 lists several things to be addressed in determining how to satisfy operational requirements.*

In Chapter 16 great emphasis is placed on the role of the Program Manager in acquisition of computer programs. I quote:

> "Early identification of computer resources, and technical and management expertise within the Program Offices is needed to manage and engineer the acquisition of functional subsystems that incorporate computer programs. The Program Manager must provide the management expertise to focus attention on computer program development and integration across the total system." (AFSCP 800–3,[22] p 16–8).

* Department of Defense Form, DD 1423.

** Chapter 8, "Engineering Management," mentions computer programs several times to emphasize differences between hardware and software and points out peculiarities of software in the systems engineering process.

* Section D, Chapter 16, is titled, "Acquisition and Support of Computer Programs." I feel this section has been placed in the wrong chapter and the AFSCP 800–3 should be revised, in accordance with the guidelines of AFR 800–14 and the ASPR, to show that computer program are *not* data.

PART IV
Summary and Observations

As software has become a large segment of weapon system development, the problems of software cost, schedule, and performance have become critical to the successful fielding of most weapon systems. The cost, schedule, and performance problems have pervaded all phases of software development and have resulted from some seemingly unsolvable problems and various sins of omission as well as commission. Among the more important difficulties have been: (1) poor requirements definition; (2) inadequate system engineering; (3) inability to track software development progress, particularly during the implementation and verification phases; (4) inadequate change and configuration control (hence changes drive costs and schedules beyond acceptable limits); (5) improper matching of test and verification with requirements; and (6) nonavailability of support software when needed, resulting in maintenance problems and higher maintenance costs.

Software does not have exclusive rights to these problems; hardware is often subject to the same problems. However, software has been prone to the greater suffering because of the failure on the part of personnel having cognizance to recognize the importance of software. There are ways to alleviate most of the problems. If the Program Manager is going to control software cost, schedule, and performance, he must recognize the potential for problems to occur and take preventative action. Significant steps the Program Manager can take include:

(1) Get the user involved early. Require an early statement of user requirements and meaningful user participation in design reviews.

(2) Insist on full incorporation of software into the system requirement analysis process. Software must be engineered as an integral part of the weapon system.

(3) Place software at a high level in the WBS and remove it from the category of "data".

(4) Make full use of planning aids such as the program management plan and the CRISP to ensure all members of the program management team know what is expected and required.

(5) Make support software a deliverable item and when applicable make it a configuration item. This is particularly appropriate when software is to be transferred to a support or using command.

(6) Organize the Program Office to provide adequate technical support for software. Assign responsibility and accountability for this support to someone other than the Program Manager who cannot be the integrator.

(7) Plan the total program budget to provide adequate funds to implement the total software development program.

One thing that is present in all aspects of what the Program Manager must do to obtain software is planning. There is an old saying in the Real Estate Business that tells the three most important things to consider when buying a house: location, location, and location. An analagous comment on software would be that the Program Manager who wants adequate software would do well to pay prime attention to planning, planning, and planning. Experience has shown that if the plan does not include software in the System Requirement Analysis, it will not be included; if you do not plan for the use of a High Order Language, there may not be enough computer memory to handle the software; if the plan does not provide for allocation of funds to support proper software development, funds will not be available for use.

A primary point is this: The Program Manager can do little to alleviate problems of inadequate software and lack of control late in the development effort. The proper steps must be implemented in the early stages to assure the availabiltiy of software at a later date. The extent to which a Program Manager has control of software is a direct function of how well he plans for software development.

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CONTEMPORARY MANAGEMENT PROFESSIONAL ASPECTS

By

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With the forces of change all about us, contemporary management must be more adaptable than ever before. Proactive management is replacing traditional, reactive management. While retaining aspects of an art and a science, management is taking a professional orientation giving rise to the questions: "Is management a profession"? Do the practitioners of modern management knowingly "...do no harm"? An examination of professional standards reveals the present position of management in our society and leads to some interesting observations.*

Evolution of Management

To separate the evolution of management as a discipline from the evolution of society in general would be difficult, if not impossible. I have not attempted to so do.

The question is whether management may be considered a profession. To some, management may appear to have passed through the evolutionary stages of an art and a science and to have gained recognition as a profession. This may be, but management retains aspects of an art and a science. Like an art, management involves the application of personal and conceptual skills; like a science, it involves the application of technical skills (methods and principles).

First, examine the term, "art." Any worthwhile human endeavor normally comes into existence as an art. Art is simply the deliberate application of skills and knowledge to accomplish some end. If this definition is applied to the activities of management, there is good cause for viewing management as an art.

Second, consider the term, "science." Examination reveals science to be motivated by a need to better understand the foundation upon which art rests. Science is the search for new knowledge through: (a) a rigorous method of data collection, classification, and measurement; (b) the establishment of hypotheses; and (c) the testing of hypotheses. Management has placed increased emphasis on the use of scientific theory and practice. This has led to new knowledge. Thus management has rightfully been called a science. At this point, art and science are recognizable as complementary concepts.

Third, note the term, "profession." Close scrutiny reveals this term to be an occupation requiring the application of a high level of education and intellectual skills. A profession then, is a calling requiring specialized knowledge, following long preparation. The life work of a doctor, lawyer, theologian or engineer falls within this definition. Yet, I believe

*Based on a paper presented by Mr. Acker at the Winter Annual Meeting, American Society of Mechanical Engineers, New York, NY, 6 Dec 76.

the term encompasses an even deeper connotation—a connotation that is apparent when the term is applied to the so-called learned professions of medicine, law and the ministry. In essence:

- *There is a matter of public responsibility.* A professional is considered by the public to be a person who is qualified by education and experience to practice in his* field as he carries out his assignment in an authoritative and responsible manner.

- *There is the requirement for continuing education.* In our society education has become a continuing process for the professional—a process that does not terminate with award of a baccalaureate degree. The professional must keep atuned to progress in his field of expertise.

Fourth, examine the term, "manager." A manager is revealed to be a person who conducts business with frugality and care. According to Drucker, he

> "...develops people. Through the way he manages he makes it easy or difficult for them to develop themselves. He directs people or misdirects them. He brings out what is in them or he stifles them. He strengthens their integrity or he corrupts them. He trains them to stand upright and strong, or he deforms them—whether he knows it or not. He may do them well, or he may do them wretchedly. But he always does them."[1]

The discipline of management has been evolving and changing dramatically over the past 75 years. In this period, there has been a remarkable series of changes in management concerns and characteristics.

From 1900 to World War I, management's principal concern was with organization for production. This was the period of man vs nature when the primary resource was raw material and the primary requirement for management was that of property management. Management was basically role-oriented.

From World War I to 1950, management's principal concern turned to the organization of organizations. In this period of man vs machine the primary resource was technology—the primary requirement for management was experience. Management was basically product-oriented.

From 1950 to 1975, management was concerned with the organization of processes. In this period of man vs man the primary resource was knowledge and expertise. The primary management requirements were education and technical competence. Management was principally service-oriented.

We now look to the 1980 to 2000 period. It will be a period of man vs time, with time serving as the principal resource. Management will be concerned with basic beliefs and values. The survival of our present pluralistic society may depend upon managers' expertise, performance, sense of dedication, and standards of value.

Professional Standards

The preceding statements lead to the proposition that management has reached a professional level. Although "profession" has been interpreted by some as being virtually synonymous with the term "occupation," it is more widely recognized as an occupation that meets a set of clearly defined standards.

One student of management, Sikula,[2] states that standards for the professional manager should include:

- A specialized body of knowledge;
- Formal educational programs;
- Societies and representative professional organizations;
- An ethical code of conduct;
- Established fees for service—with service remaining in priority ahead of the quest for economic reward; and
- A central accreditation or licensing agency.

Using these criteria as a basis, it is possible to determine the status of management in contemporary society.

*Referred to in masculine terms although the feminine is understood to apply.

ANALYSIS OF THE STANDARDS

A specialized body of knowledge devoted to the subject of management does exist. The knowledge evolved as management developed as a discipline. Some believe this body of knowledge is not organized nor systematic; others refute this statement. Suffice it to say, there are management concepts and principles. Complete agreement has not been reached as to what these concepts and principles include.

Formal educational programs are available to managers. College students can major in several fields of management. Many colleges now offer advanced degrees in specialized management fields. Large companies and the military services offer internal management development programs. Practicing managers participate in extension courses, short courses, seminars, and workshops to increase their knowledge and update managerial skills. There are a few successful managers who have not had formal education. For the most part, the latter managers received their education at the "College of Hard Knocks," i.e., through practical experience. Management-oriented societies and professionally oriented divisions within other professional groups do exist.

Two of the best known management-oriented organizations are the American Management Association and the National Academy of Management. The former organization is composed of management practitioners, while the latter organization is made up of management academicians. An example of a professionally oriented division within one of the societies would be the Management Division within the American Society of Mechanical Engineers (ASME). An analysis of other professional management organizations reveals a primary concern with the interests of specialized management groups, such as program managers, financial managers, production managers, and personnel managers.

Codes of conduct are being developed by management organizations. This is evident in current research reports and the literature developed and disseminated by these organizations. There is an even stronger move afoot to focus on managerial values, social responsibility, and ethical behavior.

Managers do charge fees. The fees may be collected as salaries or as compensation for consulting services. Whether or not service or compensation is the manager's primary motivation can only be answered by the manager himself.

Today, a central accreditation or licensing agency for professional managers is nonexistent. In this regard, management has not reached full professional status. So-called "managers" are not required to meet any standards or to pass any uniform examination before assuming a management position in an organization. In a very broad way, a college that offers an undergraduate and graduate degree in management might be considered a form of accreditation agency. However, the standards established by colleges are not uniform even though the colleges having such standards may have passed some form of accreditation inspection by a professional organization. Furthermore, general agreement has not been reached as to whether or not a central accreditation or licensing agency for managers is either necessary or desirable.

OTHER CONSIDERATIONS

Albers' simple definition of a professional appears reasonable and could serve as the basis for a standard. He says that a professional is one who has committed himself to "the learning of a systematic body of knowledge together with the skills necessary for application and conformity to an established body of standards."[3]

It appears reasonable to define professional in terms of a continuum—placing the ideal professional at one end and unorganized occupations at the other end. This approach is probably better than establishing a unique set of characteristics against which one has to make a measurement on an all-or-nothing basis. The essential characteristics of a model professional can be readily identified using the continuum approach.

According to Vollmer and Mills, the professional:

- Performs in accord with a systematic body of knowledge;

- Has authority that is based upon superior knowledge;
- Has broad social sanction and approval to exercise authority;
- Functions in compliance with a code of ethics; and
- Has a culture that is sustained by an organization—an association of professionals.[4]

Managers may not have developed the above characteristics to the same extent as traditional professional groups; however, Kast and Rosenzweig believe,

> "If we view the concept of professionalism on a continuum, it is apparent that the trend (in management) over the past several decades has been toward greater compliance with these elements of professionalism."[5]

The Professional Aspects of Military Management

Man advances, or regresses, within the structure of his society. Thus, it can be quickly determined that military officers have achieved—as have their civilian counterparts—some degree of professional status. In the military society, knowledge and skills are acquired at the service academies. Upon this foundation professional character in the military services is built. Beyond this, military officers receive periodic, intensive formal education throughout their careers.

Huntington,[6] believes the distinguishing characteristics of a professional military officer are expertise, responsibility, and corporateness. Isn't this also true of the professional manager in the civilian sector? The manager—be he military or civilian—is an expert possessing specialized knowledge and skill in a significant field of human endeavor. Pocklington,[7] describes our military officers as responsible experts, working in a social context and performing services that are essential to the functioning of society. These officers are members of a corporate group, a group that shares a unique social responsibility. In describing military officers as professionals, Pocklington adds that apart from the three elements of professionalism, a distinct sphere of military competence also exists.

MARKS OF A "PROFESSIONAL" MANAGER

A universal concept of management is that in its applied aspects, management is the practice of getting things done through others. The true marks of a "professional" manager are reflected in how well he accomplishes this task. This recognition does not come about as a result of legal registration. An accomplished manager brings to his employer (or client)

> "...a competence that is sufficient for the assignment (at hand), an eagerness to serve, a dedication to the task, an appreciation of costs, a sense of timing, a desire to communicate, a recognition of the contribution made by others, and the ability to complete the assignment in such a manner as to receive acceptance and utilization..., of the end product."[8]

The manager, to be considered as a professional, needs a certain degree of autonomy. His employer cannot expect to completely direct, supervise, or control him. Admiral H. G. Rickover, USN, once said, "Service ceases to be professional if it has in any way been dictated by a client or employer. The role of the professional man in society is to lend his special knowledge, his well-trained intellect, and his dispassionate habit of visualizing problems in terms of fundamental principles to whatever task is entrusted to him. Professional independence is not a special privilege but rather an inner necessity for the true professional man, and a safeguard for his employer and the general public."

The manager, as a professional, is private because he is not subject to political control. At the same time, he is public because the welfare of his employer establishes the limits of his deeds. The basic rule of professional ethics set forth in the Hipprocratic oath of the Greek physician 2500 years ago—"Above all, not knowingly to do harm"—is still the basic rule of the ethics of public responsibility. Drucker believes that many managers "do not realize that in order to be permitted to remain autonomous and private they

have to impose on themselves the responsibility of the professional ethic."[9] He adds, "...they still have to learn that it is their job to scrutinize their deeds, words, and behavior to make sure that they do not knowingly do harm."

If a manager in our present-day society assumes the responsibility that he has been given, strives to maintain an effective relationship with his employer or client, and carries out his assignment with sincerity and a true sense of dedication, his recognition as a professional will follow.

THE MANAGER, PART OF A SYSTEM

Finally, it should be recognized that the manager, although he has a certain degree of autonomy, is also part of a management system. This management system may be viewed as an inherently personal process. It is a process that takes place between the manager and his employer (or client) and subordinates. This relationship is most effective when the manager and his employer and subordinates have a clear and common understanding of the following:

- The role of the manager;
- The relationship of the employer/subordinates to the manager;
- The role of the employer/subordinates;
- What the manager expects of his subordinates, i.e., the performance standards; and
- How the manager measures the performance of his subordinates, i.e., the performance appraisal.

Any management system that takes these issues into consideration as a part of the normal operating environment has some of the ingredients for success. In the final analyses the key to success is the manager. He is the one who must develop a management team, as well as a system and procedures that bring about, within a specified budget, timely results that satisfy previously established objectives set forth in well conceived plans.

OVERVIEW

A most challenging intellectual problem, that of coping with change, must be faced during the last quarter of this century. We live in an age of uncertainty. Our society is not stable; it is temporary. Alvin Toffler believes we have seen the death of permanency, and that "...the individual must become infinitely more adaptable and capable...."[10]

All about us, forces of change are at work. The need for skilled leadership is apparent. We are groping to develop expertise in the management of social systems to deal effectively with such things as:

- Population growth, changing age patterns, urbanization
- Economic instability, inflation, bankruptcy
- Advances in science and technology
- New knowledge, accelerated by proliferation of information
- New laws and legal concepts
- Labor and political unrest

The change in values, attitudes and behavior, according to Harland Cleveland, call for "...new kinds of organizations, managed in new ways, by new kinds of people." To meet the challenge, traditional, reactive management (bureaucracy) is being replaced by anticipatory, proactive management.

Final Observations

Contemporary management is accepted as a discipline; it has yet to gain full acceptance as a profession. Perhaps within the next decade it will be given widespread acceptance in this respect by the public. Professional status will come about as a larger number of persons with education and scientific expertise rise to responsible positions in the management hierarchy.

Managers might accelerate public acceptance as professionals if they:

- Join to contribute to the establishment of uniform, high standards;
- Provide service principally for the benefit of society, rather than for monetary gain;

- Foster management education;
- Participate in the activities of management-oriented societies or the professionally oriented divisions within professional organizations;
- Answer the question (and act accordingly) as to whether accreditation is desirable for those who are entering the field.

The challenge is clearly before our managers. Future generations will receive the benefit if our contemporary managers meet this challenge directly, enthusiastically, and with a sense of purpose.

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ROLE OF CONGRESSIONAL STAFFS IN WEAPON SYSTEM ACQUISITION

by

John W. Allsbrook, Major, USAF

Who are the people that make up a Congressional Committee Staff? What is their role in the acquisition process? What are their responsibilities and what is their authority? Do they, in fact, influence decisions in the acquisition process? And if so, how? What are the implications to the program manager? These are some of the specifics addressed in this article.

PART I

INTRODUCTION

In recent years, the importance of the professional congressional commitee staff member has greatly increased in the weapon systems review and approval process. Committee staff members are involved heavily with both budgetary and technical details. The committee staffs work primarily for the committee chairmen and are in a position to exercise considerable influence on the decision process. They prepare committee members for hearings with briefings and documentation and at times become active participants during the hearings. The extent of staff influence depends upon the competence and initiative of the individual staffer. The confidence that the committee has in the staff is directly related to the quality of the information the staffer demands, and his ability to interpret such information and draw logical conclusions. A program manager should develop the staff's confidence through open, responsive, and forthright communication. A most critical aspect of the weapon system acquisition process is the budgeting activity that culminates in congressional approval of program funds. A congressional staff plays a very fundamental role during this decision-making process.

In order for a program to succeed, it must be accepted and approved by the Congress. This includes indorsement and support of the professional staffers and the Armed Services Appropriations Committee of both the House of Representatives and the Senate.

In the course of the program approval process, the program manager may have to appear as a witness before the committees in public or at closed hearings. Such appearances will, in most cases, be preceded by a session with one or more committee staffers. In other cases, a session with a committee staff may be the only opportunity the program manager has to defend his program to the Congress.

PART II

THE CONGRESSIONAL ENVIRONMENT

THE LEGISLATIVE PROCESS

Congressional authority over the DOD budget is rooted in the US Constitution. Article I, Section 8, of the Constitution embodies in the Congress the power "...to raise and support Armies...," "...to provide and maintain a Navy...," "...to make rules for the government and regulation of the land and naval forces...," and "...to make all laws which shall be necessary and proper for carrying into execution the foregoing powers."

One "rule" made to "regulate the land and naval forces" has been the establishment of a two-step process whereby military programs are first authorized by law and then, in a separate law, funds for carrying out the programs are appropriated. This process dates back to 1921 when the House of Representatives made a rule that appropriations could not be recommended by the Appropriations Committee for purposes not authorized by law. Similarly, another rule prohibited the substantive committees (e.g., Armed Services) from adding appropriations to the reported authorization bills. (AF/AC*,[1] p 49).

APPROPRIATION

In 1959, the two-step process began to involve a detailed review of the total military budget. At this time the process was established in public law that provided:

> "That no funds may be appropriated after December 31, 1960 to or for use of any Armed Forces of the United States for the procurement of aircraft, missiles, or naval vessels unless the appropriation of such funds has been authorized by legislation enacted after such date."

Although this provision of the law dealt only with aircraft, missile and ship procurement, the Congress soon realized the desirability of expanding the requirement to other portions of the DOD budget. Consequently, there have been seven additional amendments to public law. A specific requirement now is that research, development, test and evaluation (RDT&E); tracked vehicles, personnel strengths; and other weapons procurement (rifle, artillery, small arms, and torpedoes); be subjected to the annual authorization process prior to appropriation. (Williams,[2] pp 103–105).

POSTURE HEARINGS

How, within this two-step framework of authorization and appropriation does the Congress meet its Constitutional obligation? The process begins in January of each year when the Congress begins its regular session. Before the detailed review of individual programs, the Armed Services Committee of both the House and Senate hold military posture hearings. The posture hearings usually cover only broad aspects of the military budget including force structure and overall weapon and personnel strength levels. Witnesses usually are service officials, including the Secretary of Defense and other top OSD representatives, the Service Secretaries and the military chiefs.

AUTHORIZATION

Posture hearings are followed by the authorization hearings. The recent practice of the respective Armed Services Committees has been to hold separate hearings on procurement and Research, Development, Test and Evaluation (RDT&E). Although the principal witnesses at these hearings are normally Assistant Secretaries of the military departments and the military Deputy Chiefs of Staff, it is not unusual for a program manager to be called to testify, especially for designated major weapon systems. The primary responsibility of the witnesses is to defend and support specific programs outlined and the funds requested in the President's budget that are being considered by the Committees.

Because of the shortage of time as well as the desire for independent analysis, authorization hearings are held simultaneously in the House and Senate. However, because of the statutory requirement

*US Air Force, Office of the Comptroller.

that money bills originate in the House, the House Armed Services Committee is the first to complete its review and make any adjustments to the proposed budget. This process is referred to as bill "mark up". The marked up bill is then presented to the full House with a report containing the rationale for committee action. Without waiting for the Senate version, the House will vote on the bill after 2 or 3 days of floor debate. The Senate normally allows the DOD to submit a written appeal of the House action to include the adverse impact of any reductions imposed by the House. After considering the DOD appeal and its own analysis of the budget request, the Senate Armed Services Committee submits to the Senate its marked-up version of the bill and a report containing rationale for committee action. The full Senate, after floor debate, votes on this bill.

The result of separate House and Senate action is two different authorization bills. These differences are resolved in a conference committee made up of selected representatives from the respective Armed Services Committees. The conference committee may, during deliberation, consider only those matters that are in disagreement. The conference committee will not reconsider reductions agreed to by both Houses. During this process the DOD is once again permitted to submit a written appeal from actions under consideration. Once approved by both Houses, the authorization bill is forwarded to the President for signature.

THE TWO-STEP PROCESS

Meanwhile, the second half of the two-step process has already begun. The appropriations phase generally follows the sequence described for authorization but in different committees and with a whole new set of congressional participants. [3]*

Two general conclusions may be drawn from observing the legislative process. First, the process is long and involved and it may take from 9 to 12 months to complete. Throughout the process a program manager may be called to explain his program many times. He may be required to testify as an expert witness, or he may be tasked (usually on very short notice) to provide written answers to questions posed by Congressmen, staffers, or other Government witnesses.

*Cited for further reading on the legislative process

The second general conclusion drawn from observing the legislative process is that the heart of the process is committee activity — and, committee activity is the province of the professional staff.

STAFF ORGANIZATION AND BACKGROUND

The current concept of a professional committee staff was established in the Legislative Reorganization Act of 1946. Section 202(a) of the act provided for "...not more than four professional staff members..." on each standing committee except Appropriations Committees. Appropriations Committees, because of having the greater oversight responsibility, were permitted to hire as many persons as each respective chamber of Congress would permit. (Horn,[4] p 63). Expansion of committee staffs was authorized by another reorganization in 1970. Today, the Senate Armed Services Committee has a total of twelve professional staff members, two counselors (lawyers), and a chief counsel who serves as staff director. The House Armed Services Committee has eleven professional staff members and seven counselors, including the chief counsel. In the Appropriations Defense Subcommittees, the House has eight staff members assigned and the Senate has five. (Brownson,[5] p 159ff).

In general, committee staffs are appointed by committee chairmen. Although a staffer supports all members of the committee, primary loyalty is to the chairman. Rieselback, in his commentary on congressional politics, observes:

> "...the committee staff is the creature of the chairman: he determines who will be hired, how much assistance will be provided for the minority side, what the majority staff will do, and often the vigor with which it carries out its assignments." (Rieselback,[6] p 67).

The credentials and experience of professional staffers are varied, yet there are many similiarities. Many of the staffers have been recruited from the Executive Branch of the Government, including the Department of Defense, "...thus securing the services of persons who are already well versed in the subject matter with which the committee deals." (Harris,[7] p 115). A review of the background of

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those Armed Services and Appropriations Committee staffers who have provided a biography to the *Congressional Staff Directory* shows that the majority have at one time served on active duty with one of the military services. Some are retired military officers and at least one is currently a member of the US Naval Reserve. Others have served on the civilian side of the Department of Defense including one who served for 7 years as a Deputy Director of Legislative Liaison. (Brownson,[5] p 585ff).

Budget experience in the Executive Branch is a highly desired qualification for staff members of the House Appropriations Committee.

PART III

STAFF ROLES AND INFLUENCE

INDIVIDUAL RESPONSIBILITIES

Staff members interviewed acknowledge that it is difficult to define their duties rigorously, however the performance of certain recurring tasks is expected of the staffer. The role of the House Appropriations Committee staffer, as described by Fenno[4], is typical of that of most committee staffers:

> "...For his subcommittee, each clerk is expected to schedule and oversee the routine of the hearings, suggest areas of inquiry for the hearing, make up specific questions for use in the hearings, prepare the transcript for publication, help prepare for the mark up session, oversee the routine of the mark up, help write the subcommittee report, and the subcommittee bill, participate in full Committee, sit with and advise subcommittee members during floor debates, help schedule and prepare for conference committee meetings, prepare materials for use by House conferees, participate in conference proceedings, receive and digest reports from the investigation staff, keep in constant communication, in season and out, with agency officials, and accompany committee members when they travel to visit agency installations. His role requires that he process all the committee's working documents and that he be present physically at every stage of decision-making. "There may be some part of the process that I miss or don't know about," said one staff man, "but I doubt it." (Fenno,[4] p 182).

These responsibilities are inherent in behind-the-scenes activities that might be expected of a committee staffer. The role is important and certainly one that ensures the success of the legislative process.

HEARING PARTICIPATION

The staffer also plays another, more visible, role that is not cited by Fenno. This is the role of questioner, along with the committee members, during hearings. This role appears to be more prevalent in the Armed Services Committees than in the Appropriations Committees. For example, a review of the published hearings on FY 77 authorization bill shows that almost half of the questions asked of the Office of the Secretary of Defense and service witnesses were asked by committee staffers.[9,10]

Where the technology is advanced and the committee staff is competent, frequently the committee members assign to the staff the actual questioning of witness. The recent addition of two technically competent staff members to the House Armed Services Committee has permitted that committee to spend a greater portion of its hearing activity delving into technical issues.

STAFF INFLUENCE

The activities of the committee staff, as previously discussed, strongly suggests that the staffers have an inherent potential to influence congressional decisions on weapon systems acquisition. The exercise of influence varies, and, for a number of reasons. Patterson notes:

> "...Staff influence varies among congressional committees as a result of differences in staff availability and competence, committee workload, and structural factors in committee organization. At the same time, the potential influence of committee staffs is considerable indeed." (Patterson,[11] p 411).

In the areas of committee workload and committee structure, staff influence is very much dependent on the personality and style of the committee chairman. Fenno, in his paper on the distribution of influence in the House of Representatives, states:

> "...Staff influence varies with the confidence which committee and subcommittee members, and especially their respective chairmen, place in staff abilities and staff judgment. Where the desire to use a staff and confidence exist, staff members constitute a linchpin to internal committee decision-making. When these conditions are not present, it does not make much difference what kind of staff a committee has. Such staff influence as does exist in the House exists here—in the committees." (Truman,[12] p 66).

Similarly, Huitt comments regarding Senate staff:

> "...first rate professionals do more than carry out assignments. In the offices of individual senators they learn to think like the boss; they determine to some degree who sees him and what importunities reach him. In the committee rooms they identify the problems and provide the facts and questions. The product of the Senate is to some unmeasured and perhaps immeasurable degree their product. Their influence probably would be very easy to overstate, but it does exist..." (Truman,[12] p 113).

The growing size of the DOD budget and the increasing complexity of modern technology makes it more and more difficult for the individual congressman or senator to digest all information available. Rieselback observes,

> "...The more complex the issues, the greater the need of the lawmakers for technical expertise and the greater the opportunity for the staff to press its own views." (Rieselback,[8] p 79).

A number of committee staff members have candidly commented on their ability to influence the legislative process:

> "...I like being close to the levers of power (said one staffer on a committee unrelated to DOD). My ideas have influence only to the extent that I can persuade the Senators that they are in the public interest. The staff man can have a lot of influence in these terms. If you know you can't persuade a member to your own policy position, you lay out the alternatives, and you've got to be as objective as you possibly can." (Patterson,[11] p 411).

Regardless of how staff influence is viewed, there can be little doubt that it exists—both in potential and in daily exercise. Nevertheless, such exercise of influence that does take place does so only to the extent that it is permitted by the committee members and especially by the chairman. The staff realizes this limitation and acts accordingly. In his contact with the staff, the program manager must assume that the staff is acting for the committee and with its full consent.

INFORMATION, A SOURCE OF INFLUENCE

The amount of influence possessed by a given staffer is measured to a great extent by the intelligence he is able to obtain. Information is his stock in trade.

What are the information sources of the staff? Much of the information gathered by the staff comes from the DOD itself in various forms. The congressional inquiry is a popular channel for information flow. Such inquiry is treated by the DOD as a formal request for information and each request is treated with the same degree of importance, whether it comes from a Congressman needing information for either his own education or to reply to a constituent, or whether it comes from a committee staffer. Inquiries are normally handled through legislative liaison offices which have been established in the Pentagon by DOD and each of the military services. In addition, each service maintains a small detachment of liaison personnel located in the office buildings of both the House and the Senate. When a request for information is received (usually by telephone), it is relayed to the office having primary responsibility.

Usually the request is for written material—a position paper or a fact sheet. Occasionally, a briefing is requested and it will be conducted in the office of the staff member. This may involve having the program manager travel to Washington for the briefing.

An additional source of important program information is the justification material submitted to Congress with the President's annual budget. This justification material is in the form of several volumes that contain thousands of pages of detailed program data. The data includes funding requirements, schedules, purchase quantities, technical performance parameters, and narrative discussions of requirements and planned activities. Detailed formats and instructions for this material are contained in the *DOD Budget Guidance Manual*, DOD 7110-1-M, published by the Office of the Assistant Secretary of Defense (Comptroller). The manual is revised periodically to reflect additional or changed requirements of the respective congressional committees.

Witness statements and hearing transcripts also serve as information to committee staffers. Witness statements are required to be submitted several days in advance of hearings so that they may be analyzed by the staff for issues to be raised during the hearings. Statements of service witnesses are reviewed and compared with previously received DOD policy statements. A comparison is made of the current position of witnesses with positions taken by the same witnesses in previous hearings. And finally, the statements are compared with other information gathered by the staff. Similarly, transcripts of hearings before other committees are reviewed.

Committee staffers occasionally take a request for information directly to the program manager. Certain staff members, for example, make annual trips to military installations for the purpose of gaining first hand information on major acquisition programs. In the course of these visits, the staff members expect to be briefed on program status, problem areas, and anticipated funding needs. Field trips are taken to contractors' plants where staff members receive program briefings, talk to engineers and technicians, see and touch the hardware, and witness tests and demonstrations.

Contractors recognize the potential benefits of such visits and actively court individual staff members. The preference of lobbyists for the attention of the staff instead of that of committee members is summed by one business representative who noted, "The members are busy. They usually don't have the time to listen to a sales pitch. And often it's the staff that really matters anyway." (US News and World Report,[11] p 26).

Other outside sources of information include the research services of the Library of Congress, reports of the Government Accounting Office, technical journals and trade magazines, newspaper stories, liaison with other committee staffs, and information from such private organizations as the Brookings Institute. In fact, the wide availability of information to committee staffs has brought about increasing suggestions that staffs be enlarged to handle all data. (Harris,[7] pp 117-119 and Truman,[12] p 130). A counter argument is that more staff would only create new, more complex problems to compete for the limited attention of the congressmen and senators. At the same time, there is always the danger of creating a legislative bureaucracy that will dilute and color the information gathered by the staff, thereby in effect making the committee a captive of the staff. (Rieselback,[8] p 384).

The fact that committee staffs do not have access to a wealth of data means that they must pick and choose the data that is passed on to busy committee members. This requirement for the staff to exercise judgment provides the greatest opportunity to influence, if not actually make, the ultimate congressional decision affecting weapon system programs. Implications of this reality and the effects on program manager—congressional staff relations are addressed in upcoming paragraphs.

PART IV

PROGRAM MANAGER-CONGRESSIONAL STAFF RELATIONS

Clearly, the congressional staffer can be an important force in determining the direction and funding level of a given weapon system program. Where the staff is not convinced of the value of the program, the chances are slim that the program will advance through the congressional approval process without a reduction or redirection. Conversely, a program that makes sense to committee staff stands a good chance of approval. It is incumbent on the part of

every program manager, when the opportunity arises, to ensure that he communicates total program understanding to the appropriate members of the committee staff.

In the process of budget formulation, individual program budgets may be reduced "inhouse" by the service headquarters, OSD, the Office of Management and Budget (OMB), or even the President, before the budget is submitted to the Congress. The President's budget submission represents a balance in priorities of total demands on the nation's tax dollars. Therefore, all witnesses appearing at congressional hearings are advised by OMB Circular A-10 that:

- Personal opinions will not be volunteered which reflect positions inconsistent with the program and appropriation requests the President has transmitted to the Congress.

Witnesses are permitted, to respond to a direct request for personal opinion with the appropriate caveat:

- In expressing personal opinions relating to such program and appropriation requests in response to specific requests therefor, witnesses will refer to the extent, if any, and should make clear that the expression of the opinion is not a request for additional funds.

An attempt to lobby for additional funds with committee staff outside formal hearings would only create additional problems for the program concerned, and the budget as a whole. Issues created by an overzealous proponent might suggest that the budget as submitted does not reflect actual requirements. Such an indication could undermine the credibility of the entire budget.

Knowing the orientation and the needs of committee staff is the full time responsiblity of legislative liasion personnel in the Pentagon, and the program manager should work through these channels. Liaison personnel maintain contact with committee staff on a daily basis and have established strong relations built on trust and mutual confidence. When information is sought by committee staff from the program manager, the request is usually directed through liaison personnel. On those occasions when urgency necessitates direct contact between a staffer and a program manager, liaison personnel should be notified as soon as possible to assure that appropriate service headquarters and DOD personnel are alerted to potential congressional issues. Through frequent contact with committee staff, liaison personnel may be able to provide a measure of perspective as to what may be behind a specific request for information. This reduction of uncertainty offers greater opportunity for positive communication and less time is wasted on tangential issues.

One final comment is appropriate. Contact with a committee staffer sometimes places the program manager in a defensive role. He may find it necessary to justify his program to an individual who has an opposing view. In such situations, especially when the atmosphere is informal, extra attention must be given to maintaining high professional standards and to responding to disagreement in a reasonable, factual manner.

PART V

SUMMARY

The professional staffer on those congressional committees having oversight responsiblity for military weapon system acquisition is a key element in the budget approval process. Staffs are increasing in technical competence and growing in size. The increased competence and numbers means that probably they are going to exhibit more and more interest in technical and management decisions made by program managers.

The technical competence of committee staff combined with their knowledge of program information provides a unique opportunity to influence the budget decisions made by the Congress. Every program manager must recognize this influence. Each program manager should work to earn the confidence and commitment of committee staffers just as he would work to earn the confidence of any military staff officer or other decision shaper.

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What's Happened To The Basics?

By WILLIAM W. THYBONY

"Important principles may and must be inflexible."

—Abraham Lincoln[1]

The material presented here consists of excerpts from an article that first appeared in Vol 9, Issue 1, of the National Contract Management Journal. The author graciously revised these excerpts to update the information. To preserve the relation with the previous article and to assist the reader seeking to correlate all of the material, routine Review editorial changes were not made to this copy. The references and footnotes follow the format of the original article and not the Defense Systems Management Review format.

Editor's note.

During an era when procurement officials, professionals, and technicians, both in Government and industry, are deeply and almost totally absorbed with complex problems and exotic (and often confusing) policy and procedural requirements, it is rare to focus the spotlight on the basics of Federal procurement. Often they are only backstage scenery. Today's paper implosion on the individual makes it next to impossible to sit back and relate the solutions of daily problems to the bedrock of procurement doctrine. And yet it is a discipline that needs cultivation.

The magnitude, complexity, and diversity of Government procurement involves a huge cooperative effort and requires a high degree of understanding and education. Its impact on the level and trend of over-all economic activity in the United States is considerable, and Federal procurement programs affect almost all business firms directly or indirectly. The Government as a customer is engaged in millions of procurement actions each year, utilizing public funds which comprise a great share of the tax dollar. The great size of such an undertaking in itself solidifies the need to examine the basics.

The procurement process is beset with a good number of problems that could have been avoided. The seriousness of many would have been less, if at the outset good judgment and foresight based on the fundamentals of Government contracting had been used. Often, those in the Government procurement business, whether on the buyer or seller side, become so specialized that after time goes by they lose sight of the fundamentals. Knowledge of the basics and application on a day-by-day basis is essential. It is elementary not only to the novice, but to professionals of long standing experience as well, to be on solid ground.

[1]Last public address; April 16,1965

Current dialogue and debate is drawn to the prevailing sophisticated modes of: cost accounting standards, major systems acquisition, research and development contracting, management systems, parametric cost estimating, pie cost, independent research and development, return on investment, design-to-cost, independent research and development, return on investment, design-to-cost, "should cost," cost sharing, technical transfusion, appeals, claims, defective pricing, industrial funding, patent policy, rights in technical data, consequential damages, economic price adjustments, etc., etc. Granted, all are important — and yet many of today's issues could be simpler and procurements made sounder if they rested on a firm foundation of the basics.

The Legacy of Procurement Law

To set the prime tone it is significant to know that the hard core basics have derived from an evolutionary legislative process.

From the beginning Federal procurement has been guided by the need to acquire goods and services of specified quality on a timely basis by maximizing competition and obtaining reasonable prices, with the assurance that Government officials are publicly accountable for their actions.

The legacy of procurement law inherited by procurement officials of today has been unfolding since the founding of the nation. It represents the culmination of the efforts and contributions, through war and peace, of the courts, Congressmen, Government officials, buyers, lawyers, accountants, military leaders, civil servants, industry executives, and the general public.

Looking into the past we see a long and complex historical evolution of procurement law, beginning in 1792 when the Department of Treasury was given responsiblity for purchasing and contracting. This evolution continues to this day, and the complexity intensifies at a rapid rate. Still, despite the vast legal, legislative and procedural background of the procurement function, the meaning of the term never has been precisely fixed.

What Is Procurement?

What is procurement? In the procurement community the answer would seem so obvious that it should be unnecessary to address. But oddly there is a wide disparity of opinion. No two people will give the same answer. There is no common definition in the procurement regulations. The Armed Services Procurement Regulation (ASPR) and the Federal Procurement Regulations (FPR) differ.[24] The primary procurement laws contain no definition of "procurement," nor does the Office of Federal Procurement Act.[22]

Consequently, since a summation on procurement basics calls for such a definition, for the purpose of this paper "procurement" means the act or process of obtaining or acquiring property or services to meet a public need by the payment of money or its equivalent. In its most acceptable sense, it encompasses purchasing, contracting, renting, leasing, and bartering. It includes the functions of advance procurement planning; description (but not determination) of requirements; solicitations for bids or proposals (including the preparation and publicizing of solicitations) based on expressed needs of what, where and when; the submission of bids or proposals; evaluation of bids and proposals; conduct of negotiations; selection of contractors and the preparation and award of contracts; and the administration of contracts to final payment and completion.

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[22] P.L. 93-400; August 30, 1974, 88 Stat. 796

[24] ASPR 1-201.13; FPR 1-1.209.

What Are The Basics?

The basics of Federal procurement have grown and matured over the years through a maze of not only varied legislative, but administrative efforts as well, to develop a system providing safeguards against graft, favoritism, questionable ethics, war profiteering, collusion, and inefficiency, and to protect the integrity of the competitive and public bidding system once established.

What then are the real basics? Here again there will not be full agreement. Why? Because they are not compiled in any one law or regulation, and opinions of individuals will vary depending on their specialization, knowledge, and the divergent missions of their organizations.

However, in spite of this and from a broad and objective perspective, the condensation set forth below is offered as representative of the basics of Federal procurement. There can't be any quarrel with the statements included — there may be dispute as to whether the list is all-inclusive. Miss any one of the following and you're in trouble:

1. The power of the United States to contract is based on the general and implied powers contained in the Constitution of the United States.

2. The President of the United States, as the Nation's Chief Executive Officer, is responsible for Government purchasing functions.

3. The Administrator for Federal Procurement Policy (head of the Office of Federal Procurement Policy in the Office of Management and Budget) by law provides overall direction of Government procurement policy.[22]

4. Upon entering a contract the Government becomes subject to the rule of Federal law as a private individual.[25]

5. The U.S. Government as a contractor is not liable for its soverign acts.[26]

6. No contract or purchase on behalf of the United States can be made unless it is authorized by law or is under an appropriation adequate to its fulfillment. A contract liability expires when the appropriation is exhausted.[27]

7. Expenditures or contract obligations in excess of funds appropriated are prohibited. (Anti-Deficiency Act).[28]

8. Federal agencies may make use of funds only for the purpose appropriated, in the absence of specific authority for another purpose.[29]

9. No contractor can be required to perform a Government contract in a manner prohibited by law or in response to coercion or promised reward by a Government official or employee.

10. No official or employee of the Government may give away any vested right of the Government.

11. The Government contracting officer is the agent of the Government under any Government contract. His authority is limited. A Government contracting officer may bind the Government only to the extent of his actual authority, whether it be expressed or implied. Authority may be implied from a duty imposed upon the Government agent or from some express authority given to him.

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[22]P. L. 93-400; August 30, 1974, 88 Stat. 796

[25]U.S. v. *Allegheny County*, 322 U.S. 174 (1944), and in Re *American Boiler Works*, 220 F. 2d 319 (1955).

[26]*Jones v. United States*, 1 Ct. Cl. 383, 385 (1965).

[27]42 U.S.C. 11, *Shipman v. United States*, 18 Ct. Cl. 138 (1883), 37 Comp. Gen. 199 (1957).

[28]31 U.S.C. 665(a), ("Anti Deficiency Act").

[29]28 Comp. Gen. 38 (1948).

12. The risk of dealing with a Government agent not authorized to act like a private contractor, when a Government agent does not have actual authority to act, the Government is not bound by his acts.

The Supreme Court has said:

> Although a private agent, acting in violation of specific instructions, yet within the scope of his general authority, may bind his principal, the rule as to the effect of the like act of a public agent is otherwise, for the reason that it is better that an individual should occasionally suffer from the mistakes of public officers or agents, than to adopt a rule which, through improper combinations or collusion, might be turned to the detriment and injury of the public.[30]

13. The Government is required to acquire goods, services, and facilities of the requisite quality and within the time needed at the lowest reasonable cost, utilizing competitive procurement methods to the maximum extent practicable.[22]

14. The Government relies upon the private enterprise system to supply its needs, except where it is in the national interest for the Government to provide directly the product or services it uses.[31]

15. The two principal methods of procurement and forming of contracts are formal advertising and negotiation. Formal advertising is the preferred method, unless it is not feasible or practicable and one of the statutory exceptions to formal advertising is applicable — then the procurement may be negotiated.[32] The Commission on Government Procurement concluded that statutory changes should be made which would require formal advertising when conditions justify its use, but that negotiated procurement should be authorized and recognized as an acceptable and normal alternative to formal advertising.[21] S. 2309, introduced by Senator Percy in the 94th Congress would have implemented the Commission's recommendations in this respect by authorizing the following methods of procurement: small purchase procedures, formal advertising, competitive negotiation, and noncompetitive negotiation. S.3005, introduced by Senator Chiles, also in the 94th Congress, contained the same provisions, except noncompetitive negotiation would have been considered an exception rather than an authorized method of procurement. Similar recommendations have been made in the past. Notable among them are recommendations contained in the National Security Industrial (NSIA) Defense Acquisition study[33] and in an article by Robert B. Hall, U.S. General Accounting Office.[34]

16. Known qualified suppliers are given an equal chance to compete.

17. In negotiated procurements, written or oral discussions are conducted with responsible offerors within a competitive range, price and other factors considered.

18. Contract awards are made only to firms submitting bids or offers which are the most advantageous to the Government, price and other factors considered.

19. Contracts are not awarded unless the price is deemed to be reasonable.

20. Normally, reasonableness of price is based on adequate price competition (forces of competition in the market place) and is determined by price analysis.

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[21] Volume 1, Report of the Commission on Government Procurement, December 31, 1972.

[30] *Whiteside v. United States*, 93 U.S. 247,257 (1876, U.S. Supreme Court.

[22] P. L. 93-400; August 30, 1974, 88 Stat. 796

[31] Office of Management Budget (OMB) Circular No. A-76, August 30, 1967.

[32] 10 U.S.C. 2304; 41 U.S.C. 253

[33] Recommendation 32, National Security Industrial Association Defense Acquisition Study, July 1970.

[34] *The Armed Services Procurement Act of 1947 Should Be Reformed*, Robert B. Hall, U.S. General Accounting Office, National Contract Management Journal, Vol. 3, No. 1, Spring 1969.

21. Generally, in negotiated procurements where price has not been based on the competitive forces of the market place, offerors are required to submit cost or pricing data to assure reasonableness of price or cost estimates and to form a basis for cost analysis. (The "Truth in Negotiations Act"[20], briefly stated, requires that prior to the awards of noncompetitive contracts and all contract modifications exceeding $100,000, prime contractors and subcontractors will have to submit to the buyer cost or pricing data certified as to its accuracy, completeness and currency. It allows the Government to reduce the contract price of the prime contract if it is later determined that the data submitted as of the date of the price agreement were not accurate, complete and current [defective data]. Only downward adjustments of price are considered.)

22. Contracts are priced separately and independently, and no consideration is given to losses or profits realized or anticipated in the performance of other contracts.

23. Contracts are awarded only to those who are responsive to the Government's requirements and are technically and financially able to perform.

24. Government contracts promote equal employment opportunities for all persons, regardless of race, color, religion, sex, or national origin.

25. Government contracting promotes small business, including minority business enterprises.[35]

26. U.S. domestic source products are preferred over foreign products.[36]

27. Fair dealing and equitable relationships are fostered between the parties.[22]

28. Items supplied by a contractor are inspected and accepted by the Government before payment of invoices.

29. Legal and administrative remedies are designed to provide for fair and equitable treatment of the contracting parties.

The basics such as those in the above digest should be officially determined and published in the Armed Services Procurement Regulation and the Federal Procurement Regulations, and thereafter all content of these regulations should be tested aginst and be consistent with the basic policy statements and principles. Donald N. Pitts, TRW, writing in a News Letter of the National Contract Management Association stated: "I urge all in the Government contracting community to promote the concept and to apply their professional experience to the development of a set of Federal Procurement Principles, which ultimately must be established. Only by establishing and building up from a solid foundation can we ever hope to achieve greater efficiency in the expenditure of public funds in Government procurement."[37]

What Is A Contract?

A contract is the prime instrument used by the Government to obtain supplies and services from private business firms and other organizations. Generally, the law that determines the essential validity of Government contracts is similar to that which governs private contracts.

In this sense, a contract is an agreement which creates an obligation. Its essentials are competent parties, subject matter, a legal consideration, mutuality of agreement, and mutuality of obligation.[38] In its simplest form it is nothing more than a system of legally enforceable rights and obligations.

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[20] Appendix G, Commission on Government Procurement Report, December 31, 1972.

[35] 15 U.S.C. 631 – 647 (Small Business Act of 1953, as amended).

[36] 41 U.S.C. 10(a) – (d) (Buy American Act).

[22] P. L. 93–400; August 30, 1974, 88 Stat. 796

[37] *More Comments: Federal Procurement Principles*, Donald N. Pitts, TRW, National Contract Management Association News Letter, March 1972.

[38] 17 Corpus Juris Secundum, Contracts la.

Contracts require the essential elements of offer and acceptance. These elements constitute the means by which a contract is consummated and the absence of either element prevents the formation of a contract. In Government procurements, the invitation for bids, request for quotations or proposals constitutes a request by the Government for offers of a certain nature. The bid or proposal submitted by the party solicited is in fact the offer and the subsequent contract award constitutes acceptance.[39] An offer cannot be revoked after its acceptance without the acceptor's consent; but it may be revoked at any time before acceptance, even though it allows a specified time for acceptance, unless it is under seal or supported by a consideration.[40] While under ordinary principles an offeror may withdraw or modify his offer at any time prior to acceptance, a distinction has been drawn when an offer in the form of a bid is made to the Government. In that situation, where there is no mistake, or unreasonable delay, the offer may be withdrawn or modified as a matter of right only until the date and hour set for opening of bids. Subsequent to bid opening, the Government has the power to award a contract, on the basis of the offer submitted, for a specified period of time.[39]

Most commercial relationships expressed in contracts are relatively simple compared to the usual Government contracts, which are normally complex, lengthy documents whose award and performance are controlled by equally complex statutes and regulations. Also, there are essential differences in Government contracts, as compared to commercial agreements, which make them unique.

For instance, the Government may change its mind and unilaterally terminate a contract for its own convenience; it may issue changes in delivery points, method of shipment, and specifications during performance without the contractor's consent; and if the company has a dispute with the Government contracting officer, the decision may be appealed, but it is resolved by one party to the contract — the Government, through its Boards of Contract Appeals. And an apparent contract is not a contract if the contracting officer acted beyond his authority, even though the contractor relied to his detriment upon unauthorized representations. The courts have reasoned that the risk of doing business with an authorized contracting officer should, as a matter of policy, fall on the individual contractor rather than the general public.

In brief, the prerequisites for the formation of a Government contract are: (1) any formal execution as required by statute or regulation; (2) a specific appropriation adequate to the contract or general contractual authorization; (3) the agent of Government has actual authority or his act is ratified by a person with authority; and (4) the resultant contract is not prohibited by some statute or regulation pursuant to a statute.[39]

The primary procurement regulations differ somewhat in their definitions of a contract.

The Federal Procurement Regulations state that "contract" means establishment of a binding legal relation basically obligating the seller to furnish personal property or or nonpersonal services (including construction) and the buyer to pay therefor. It includes all types of commitments which obligate the Government to an expenditure of funds and which, except as otherwise authorized, are in writing. In addition to a two-signature document, it includes all transactions resulting from acceptance of offers by awards or notices of awards; agreements and job orders or task letters issued thereunder; letter contracts; letters of intent; and orders, such as purchase orders, under which the contract becomes effective by written acceptance or performance. It also includes contract modifications.[41]

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[39] *Government Contract Principles*, Office of General Counsel, U.S. General Accounting Office, November 1970.

[40] 17 Corpus Juris Secundum, Contracts 50.

[41] FPR 1-1.208.

The Armed Services Procurement Regulation defines "contracts" as meaning all types of agreements and orders for the procurement of supplies or services. It includes awards and notices of award; contracts of a fixed-price, cost, cost-plus-a-fixed-fee, or incentive type; contracts providing for the issuance of job orders, task orders, or task letters thereunder; letter contracts, and purchase orders. It also includes supplemental agreements with respect to any of the foregoing.[42]

A wide variety of types of contracts are authorized for Government contracting.[43] They are normally classified according to compensation for cost of performance and the amount and type of profit incentive offered the contractor to meet or exceed specified targets.

Selection of contract type is determined by such factors as the financial liability of the Government, the adequacy of cost information furnished by the contractor, the nature of the work, associated risks, and current market conditions.

Many serious problems would be prevented if the contractor was completely familiar with all of the provisions in his Government contract. It is imperative that he know precisely what is required of him; he should know his rights and responsibilities.

Too frequently a Government contractor has learned too late that prescribed contract "boilerplate," although a formality, means what it says, and that its stringent provisions may be invoked against him. It is basic to know that the Government is not allowed to have a heart in administering contracts. A contractor must produce strictly in accordance with the specifications of his agreement with the Government and within the delivery time specified, or he may have his contract terminated for default with consequences that could be disastrous for him.

What Are the Ethics?

Corollary to the basics of procurement policy are the basic standards of conduct relating to the public/private interface.

Businessmen selling to the Government and Government employees assume responsibilities of ethical conduct which are greater than found in the private commercial world. In Government procurement, the principles of honesty, integrity, fair dealings and public confidence are requisite. The involvement of public interests and the expenditure of public funds demand an impeccable standard of conduct.

The underlying policy for Government officials and employees is that: where Government is based on the consent of the governed, every citizen is entitled to have complete confidence in the integrity of his Government, and each individual officer, employee, or adviser of Government must help to earn and must honor that trust by his own integrity and conduct in all official actions.

In consideration of the paramount importance for maintaining the highest possible standard of excellence of human conduct in Government/contractor relationships, a large body of laws, executive orders, regulations, and directives dealing with ethical practices and the conduct of individuals has evolved over the years. However, not all of the ground rules are in writing; some are based on custom and require the use of common sense and the experience of sound judgment.

[42] ASPR 1-201.4

[43] FPR Subpart 1-3.4; ASPR III, Part 4.

From the mass of requirements and prohibitions, a pattern for guidance unfolds, although it is cautioned that pertinent statutes and directives must be known and complied with. The following is a compendium which embraces the cardinal principles of required and acceptable ethical practices:

1. A Government employee **should**:

a. Put loyalty to the highest moral principles and to country above loyalty to persons, party, or Government department.

b. Expose corruption whenever discovered.

c. Conduct himself in such manner that his work is effectively accomplished while observing the requirements for courtesy, consideration, and promptness in dealing with the public and other Government personnel.

d. Perform business dealings with contractors and potential suppliers in a manner above approach in every respect, and assure that his conduct is such that he would have no reticence in making a full public disclosure of his actions.

e. Refrain from any private business or professional activity which would place him in a position where there is a conflict between his private interests and the public interests of the United States, including the avoidance of an appearance of such a conflict.

f. Conduct all business with Government suppliers on an arm's length relationship basis.

2. A Government employee **should not:**

a. Solicit or accept directly or indirectly, any gift, gratuity, favor, entertainment, loan, or any other thing of monetary value, either directly or indirectly from any individual or organization which has, or is seeking to obtain, contractual or other business or financial relationships with his agency.

b. Give preferential treatment or special favors to anyone, whether for remuneration or not.

c. Lose complete independence or impartiality of action.

d. Affect adversely the confidence of the public in the integrity of the Government.

e. Use any information coming to him confidentially in the performance of Governmental duties as a means for making private profit.

f. Have a direct or indirect financial interest that conflicts substantially, or appears to conflict substantially, with his official duties and responsibilities.

g. Engage in, directly or indirectly, a financial transaction as a result of, or primarily relying on, non-public information obtained through his official employment.

h. Receive any salary or anything of monetary value from a private source as compensation for his services to the Government.

i. Recommend or suggest the use of any nongovernment person or organization offering services as intermediary, consultant, agent, represenative, attorney, expediter, or specialist, for the purpose of assisting in any negotiations, transactions, or other business with his agency.

j. Knowingly, and wilfully, conceal or cover up a material fact, or make any false or fictitious statement in connection with any official matter, document, or record.

k. Wilfully and unlawfully, conceal, remove, mutilate, falsify, or destroy any Government document or record.

l. Make private promises of any kind binding upon the duties of office, since a Government employee has no private word which can be binding on public duty.

3. Contractors are **prohibited** from:

a. Offering or giving gratuities, such as entertainment or gifts, to any officer or employee of the Government with a view toward securing contracts or securing favorable treatment with respect to the awarding or amending, or the making of determinations with respect to the performing of such contracts.

b. Knowingly promising or offering compensation to a Government employee or officer for any services rendered by him.

c. Bribing public officials, such as giving or promising anything of value to an officer or employee of the Government with the intent to influence any official act or to influence such employee to commit or allow any fraud upon the Government or to influence any such employee to violate his lawful duty.

d. Employing or retaining any person to solicit or secure a contract under an agreement or understanding for a commission, percentage, or contingent fee (except bona fide employees or bona fide established commercial or selling agencies maintained by the contractor for the purpose of securing the pertinent business).

e. Submitting false or fraudulent claims or statements to the Government.

f. Submitting bids or proposals which have not been arrived at independent from consultations or agreements with competitors for the purpose of restricting competition.

The Federal Procurement Regulations and the Armed Services Procurement Regulation state that the term "improper influence" means influence, direct or indirect, which induces or tends to induce consideration or action by any employee or officer of the United States with respect to any Government contract on any basis other than the merits of the matter.

There are many areas not precisely covered by law or regulation or contract clause. These are the areas where good judgment has to be exercised. For instance, common courtesies and amenities are not gratuities if they are not offered with a view of obtaining favorable treatment in procurements. However, since it is not always possible to know the intent of the giver or the recipient, gifts or other favors even though small in value should not be given or offered to avoid embarrassment or need for explanation. It is far more prudent to lean in the direction of conservatism and prudence. It is emphasized that even the appearance of trying to influence or being influenced or the appearance of a possible conflict of interest should be fervently shunned.

CONCLUSION

What's happened to the basics? Not a thing. They haven't vanished — they've been with us right along. It's whether we consciously apply them to our problems, whether every training course is introduced by them, whether we recognize in them the roots of our professional knowledge.

The basics aren't balloons of tokenism. They are the respectable pillars of procurement.

"But I have said enough. I hope you will treasure up the instructions I have given you, and make them a guide to your feet and a light to your understanding."[4]

—Mark Twain

[4]Essay, *Advice to Youth*, Mark Twain.

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The purpose of the Defense Systems Management Review is to disseminate information regarding new developments and effective actions taken relative to the management of defense systems programs and defense systems acquisition.

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